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ABSTRACT

This report examines the patterns of teacher attrition among full-time teachers in Indiana from 1965 to 1987. The study's objectives were to assess the current state of teacher supply and demand in Indiana, recommend policies to ensure an adequate supply of certified teachers, and provide the Indiana State Department of Education with the capability to monitor and perform future assessments of teacher supply and demand. The introduction outlines a rationale for the study and provides definitions of attrition. The report goes on to present and discuss a theory of teacher attrition, to examine trends in attrition in Indiana and patterns of attrition among new teacher cohorts, and to analyze attrition over the career and over the first four years after entry using multivariate analysis. Study findings include, among others: (1) both annual and permanent teacher attrition rates have fallen steadily over time with the exception of a period in the late 1970s characterized by involuntary reductions in staff; (2) attrition in entering cohorts of new teachers is at its lowest level in 25 years; and (3) lower attrition of women teachers during early to mid-career accounts for a significant portion of the overall attrition decline. An appendix provides regression estimates for Cox models of teacher attrition. The main report is preceded by a substantial summary of its contents. (Contains 28 references.) (JDD)

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# Patterns of Attrition Among Indiana Teachers, 1965–1987

David W. Grissmer, Sheila Nataraj Kirby

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# Patterns of Attrition Among Indiana Teachers, 1965–1987

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with Priscilla M. Schlegel, Robert Young

Supported by the
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# PREFACE

This report, one in a series focusing on Indiana teachers, presents findings regarding the patterns of teacher attrition among full-time teachers in Indiana from 1965–87. The analysis was undertaken as part of a larger study of teacher supply and demand in Indiana funded by Lilly Endowment Inc. The study required and received excellent support and cooperation from the Indiana State Department of Education. The objectives of the study are to assess the current state of teacher supply and demand in Indiana, to determine and recommend policies to ensure an adequate supply of certified teachers, and to provide the Indiana State Department of Education with the capability to monitor and perform future assessments of teacher supply and demand.

The present report details research on the most important component of teacher demand, namely, teacher attrition. Companion reports address teacher supply and the role of the Beginning Teacher Internship Program in Indiana in retaining first-year teachers and maintaining their level of job satisfaction.[1] A future report will integrate the results using a pc-based model of teacher supply and demand that will address questions of possible teacher shortages.

The Indiana data provide a unique opportunity to look at teacher attrition over 23 years—probably the longest longitudinal database kept by any state. This period has been one of extreme change in the teaching profession. The 1960s saw rapid growth in the number of teachers and in real salaries to accommodate the baby boom, whereas the 1970s saw enrollments plummet and reductions in the teaching force. The 1980s saw a more stable but much older teaching force with rising salary levels. The database provides a unique window through which one can examine the effects of these turbulent changes on the level and causes of teacher attrition.

Although the results use Indiana data, the patterns of attrition and the factors that have led to a decrease in teacher attrition rates during this period are probably mirrored in many other states. The authors find that the factors explaining the trends in Indiana are the increased labor-force participation of women, the aging of the teaching force, the increased entrance of older women into teaching, the declining student/teacher ratio, and the increase in salaries. These trends have occurred nationwide, and although individual states may experience variations of their own, the nationwide trends probably dominate any state-specific factors. Thus, the results presented here may be useful in understanding teacher attrition trends nationwide. The results should be of interest to educators and policymakers in all states and nationally who are concerned with issues of teacher supply and demand.

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[1] S. N. Kirby, D. W. Grissmer, and L. Hudson, *New and Returning Teachers in Indiana: Sources of Supply*, RAND, R-4049-LE, 1991; and L. Hudson, D. W. Grissmer, and S. N. Kirby, *New and Returning Teachers in Indiana: The Role of the Beginning Teacher Internship Program*, RAND, R-4048-LE, 1991.

# SUMMARY

## INTRODUCTION

Teachers have come under increasing scrutiny over the past several years as part of the continuing national debate on the quality and appropriateness of American schooling. Issues that have been raised focus on the quality of the teaching force, the adequacy of teacher compensation, the potential for teacher shortages, and the patterns and magnitude of teacher attrition. Much of the reporting on these issues paints a fairly bleak picture: a teaching force underpaid and declining in quality with high rates of attrition and looming shortages.

Part of the debate was triggered by an earlier RAND report[1] that warned of the potential for a crisis in the teaching profession unless policies to restructure it were pursued. The trends cited as contributing to a potential shortage were increasing enrollments, an aging teacher force nearing retirement, low enrollments in teacher training programs, the more attractive professional opportunities for women outside teaching, and teaching conditions that deter the best students from entering and staying in teaching. These conditions included low pay levels, poor working conditions, and little autonomy over teaching practices.

The earlier report triggered new efforts aimed at analyzing critical issues such as the supply and demand for teachers, teacher compensation, teacher attrition, and the quality of the teaching force.[2] One conclusion of this research was that almost no data existed at the national level[3] to examine these questions and that perhaps some of them were best addressed at the state level. States often had reasonably good data with which to address questions of supply and demand, and much of the focus of recent research has been at the state level.

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[1] L. Darling-Hammond, *Beyond the Commission Reports: The Coming Crisis in Teaching*, RAND, R-3177-RC, July 1984.

[2] D. M. Gilford, and E. Tenenbaum (eds.), *Precollege Science and Mathematics Teachers: Monitoring Supply, Demand and Quality*, National Academy Press, Washington, D.C., 1990; D. W. Grissmer and S. N. Kirby, *Teacher Attrition: The Uphill Climb To Staff the Nation's Schools*, RAND, R-3512-CSTP, August 1987; A. E. Wise, L. Darling-Hammond, and B. Berry, *Effective Teacher Selection: From Recruitment to Retention*, RAND, R-3462-NIE/CSTP, January 1987; G. W. Haggstrom, L. Darling-Hammond, and D. W. Grissmer, *Assessing Teacher Supply and Demand*, RAND, R-3633-ED, May 1988.

[3] Part of that gap has been filled by the Schools and Staffing Surveys (SASS) and the Teacher Followup Survey (TFS) sponsored by the Department of Education. See, for instance, S. A. Bobbitt, F. Faupel, and S. Burns, *Characteristics of Stayers, Movers and*

The present study was funded by a grant from Lilly Endowment Inc. It is one of several[4] that use unique data from states to explore questions of teacher supply and demand, teacher attrition, and teacher quality. This study focuses on Indiana public school teachers. The data we have are unique among the states analyzed to date in that they cover 24 years (from 1964–65 through 1988–89)—the longest by far of any other databases analyzed. Teachers can be tracked year by year to determine when they enter, when they leave, and whether they return. These data, combined with measures of teaching salaries, student teacher ratios, and historical trends in labor-force participation rates and the median income of full-time workers (which can be regarded as a proxy for the opportunity costs of teaching), can not only help shed light on the behavior of teachers in the labor force and the potential for teacher shortages but can also help inform policies aimed at improving the quality of teachers.

Although our focus is on Indiana and Indiana teachers, the study will also improve our understanding of potential national-level shortages as well. National estimates have generally been based on sparse data and simplistic models of supply and demand. These simplistic models, based on inadequate information about the sources of teacher supply and the factors important in predicting teacher attrition, predict severe shortages at both the state and national levels. State-level analysis can help determine whether the critical factors influencing changes in components of supply or demand are peculiar to states or

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*Leavers: Results from the Teacher Followup Survey, 1988–89,* National Center for Education Statistics, DR-SAS-88/89-1.0, June 1991.

[4] Richard Murnane and colleagues have analyzed data from Michigan and North Carolina. See R. J. Murnane and R. J. Olsen, "The Effects of Salaries and Opportunity Costs on Length of Stay in Teaching: Evidence from North Carolina," *Journal of Human Resources*, Vol. 25, pp. 106–124, 1990; R. J. Murnane and R. J. Olsen, "The Effects of Salaries and Opportunity Costs on Duration in Teaching: Evidence from Michigan," *Review of Economics and Statistics*, Vol. 11, pp. 347–352, 1989; R. J. Murnane and M. Schwinden, "Race, Gender, and Opportunity: Supply and Demand for New Teachers in North Carolina, 1975–1985," *Educational Evaluation and Policy Analysts*, Vol. 11, pp. 93–108, 1989; R. J. Murnane, J. D. Singer, and J. B. Willett, "The Influences of Salaries and Opportunity Costs on Teachers' Career Choices: Evidence from North Carolina," *Harvard Educational Review*, Vol. 59, pp. 325–346, 1989; and R. J. Murnane, J. D. Singer, and J. B. Willett, "The Career Paths of Teachers: Implications for Teacher Supply and Methodological Lessons for Research," *Educational Researcher*, pp. 22–30, August/September 1988.

are national trends. If the latter, then improved national models can be developed.

Among specific questions that we address using Indiana data are:

- Are teachers leaving the profession at growing rates?
- What roles do compensation and working conditions play in retaining teachers within the profession?
- Are shortages of teachers likely?
- Are more attractive job opportunities increasing attrition rates for women teachers?
- What types of teachers stay longest in the profession?
- How do attrition rates differ by subject taught?

To fully address the issue of shortages, quantitative research into the separate components of supply and demand is needed. This research must provide credible explanations for the historical trends we see in each component of teacher supply and demand to produce good forecasts. The longer the time period for which we have historical data, the more credible the explanations for previous trends. Thus the data from Indiana become important in developing models of the individual components of teacher supply and demand and in testing an integrated model to predict teacher shortage or surplus.

## IMPORTANCE OF MEASURING AND MONITORING TEACHER ATTRITION

Accurate measures of teacher attrition are needed to serve several important planning and policy objectives. First, attrition rates largely determine how many teachers need to be hired each year; they thus play a significant role in assessing future teacher shortages. Because of this, it is crucial to measure and predict attrition accurately. Predicting attrition is the most important and the most difficult of the components of supply and demand. Without credible predictions of attrition, teacher shortages cannot be addressed. Such predictions are difficult to make because of the rapid changes that have occurred in teacher attrition rates over time and because of the multiple and changing factors that affect teacher attrition rates. Analyses of the Indiana data allow testing of these hypotheses and enable us to paint a fairly clear picture of the future of teacher attrition rates.

Second, attrition rates—when accurately measured and interpreted—can provide good indicators of the relative adequacy of compensation levels and working conditions within the profession. Low salaries and poor working conditions lead to high attrition and point to a need for increased spending in these areas. Low attrition combined with strict entrance standards probably indicate that salaries and working conditions are competitive; however, low attrition levels could also indicate that entrance standards are low and that those attracted to teaching do not have attractive alternative opportunities.

Third, differential patterns of attrition across subjects may point to the inadequacy of a uniform system of compensation such as the one characterizing the teacher labor market. Without pay differentials to compensate those with highly marketable skills, we risk having high turnover among these teachers with perhaps a significant deterioration in the quality of teaching in these areas.

## DEFINITIONS OF ATTRITION

There are several different ways to measure attrition, and it is critical to match the appropriate measure with the policy or planning problem.[5] In this research, we measure attrition in two ways. The traditional measure of attrition is the proportion of teachers who leave annually. We refer to this as annual attrition. However, our data show that between one-fourth to one-third of those who leave in any given year return to Indiana public schools in subsequent years. We thus define a second measure, called permanent attrition, that takes into account these returns. More precisely, annual attrition is the proportion of the teaching force in any given year that leaves during or at the end of that academic year. Permanent attrition, however, accounts for later returns by looking at all future years to see whether those leaving teachers return to teaching. If they do, they are not counted as leavers in the particular year that they left. Teachers are counted as leavers only when they do not return during the time period for which we have data.

We examine overall and disaggregated attrition rates among the total teaching force. Trends in these estimates, although useful, can be misleading if the composition of the overall teaching force changes over time. Thus in this research we focus primarily on what we refer to as cohort attrition in which we examine the attrition patterns of cohorts of newly hired, inexperienced teachers. Most attrition occurs during the first five years of teaching. It is during this critical period that individuals make career decisions to teach or to pursue other occupations. If policies to improve the quality of the teaching profession are to succeed, they must focus on keeping the best teachers during their initial years of teaching.

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[5] See Grissmer and Kirby (1987) for illustrations of this point.

For these cohorts of teachers, we estimate annual and permanent attrition rates year by year. For example, for the entering cohort of inexperienced teachers in 1965–66, we estimate how many teachers leave temporarily or permanently in each succeeding year through 1988–89. We compare cohort attrition rates for each entering cohort from 1965–66 to 1985–86. We then estimate "survival" functions that allow us to measure differences in attrition trends among various groups categorized by gender, age at entry, and primary teaching assignment. Our multivariate models allow us to analyze how attrition is affected by changes in beginning teacher compensation, salary growth ratios (which attempt to control for the growth or erosion in real teacher incomes), outside wage opportunities, labor-force participation rates, and student-teacher ratios (which act as a proxy for changes in working conditions in the profession). All these measures have changed dramatically between 1965 and 1988, and the long history we have on teacher cohorts allows us to estimate the effect of these variables on teacher attrition.

## RESULTS

**Both annual and permanent teacher attrition rates have fallen steadily over time with the exception of a period in the late 1970s characterized perhaps by involuntary reductions in staff.** Annual attrition, which was at an all-time high of 15 percent in the late 1960s, now stands at less than 5 percent. The permanent attrition rate has mirrored this decline, falling from 11 percent in 1969 to an estimated 3 to 4 percent in 1987. Part of this decline can be attributed to the demographics of the teaching force. In the late 1960s and early 1970s, the teaching force, hired in response to the rapid expansion in enrollments stemming from the baby boom, was predominantly a younger force with almost 40 percent being under 30 years old. By the 1980s, this teaching force was predominantly a mid-career force, with only about 12 percent being younger than age 30. Younger teachers have much higher attrition rates (approximately 15–25 percent) than do older teachers (2–4 percent by mid-career). Thus, lower annual attrition can be partially attributed to the aging of Indiana's teaching force. This trend in shifting age distributions of teachers also has occurred nationally, and would be expected—other things equal—to lower national attrition.

However, this does not address the important question of whether *younger entering teachers* are staying longer and the related question of whether better pay and working conditions are influential in teacher attrition. Younger teachers are more sensitive to changes in salary, working conditions, or outside wage opportunities; thus their attrition patterns are key indicators of the need for improvements within the teaching profession.

**Attrition (both annual and permanent) in entering cohorts of new teachers is also at its lowest level in 25 years.** For the 1965–66 entering cohort, one-half had permanently left teaching in Indiana by the end of the fifth year. For the 1980–81 cohort, only about one-third had permanently left teaching in Indiana by the end of the fifth year—a reduction in cohort attrition of 33 percent. Early attrition for the 1981–82 through 1986–87 cohorts is also significantly lower, although, of course, we do not have as long a history for these cohorts. We estimate that the five-year permanent attrition rates from these later cohorts may be as low as 25 percent.

Although permanent cohort attrition rates of one-quarter to one-third during the first five years might still seem high, it is important to place them in perspective. Much of this early attrition results from the normal turbulence associated with early family formation and spouse job changes, and is an expected pattern of high job and geographic mobility for individuals early in any career, not just teaching. Some of these teachers move from Indiana because of marriage and spouse job changes and probably return to teaching in other states; some may leave teaching because their performance does not come up to standard and their contracts are not renewed; some may choose to leave teaching because they feel an alternative career might suit them better. Much of this turbulence may be desirable or unavoidable and may reflect life-cycle patterns that are not peculiar to the teaching profession.

**Teacher attrition patterns by age group in each of the 23 years follow a U-shaped curve common to other occupations and professions, and predicted by life-cycle career patterns and human capital investment theories.** The U-shaped relationship between age and attrition holds true not only over a single year but in each of the 23 years. Attrition among younger teachers, those age 20–24 years, tends to be rather high compared with the average attrition for all ages. Over time, as attrition has declined, the U-shaped curve relating age to attrition has tended to move down as well, while still retaining its U shape. For young teachers between 22 and 24 years, attrition was 23 percent in 1965 and 13 percent in 1985 compared with average attrition for these two years of 12.4 and 5.6 percent, respectively. The attrition rate falls with age, being the lowest for teachers age 45–54 years. For these teachers, attrition is between 2 and 4 percent. Attrition, not unexpectedly, is higher (10–17 percent, depending on the year at which we are looking) for those age 55 and over, who are eligible for retirement.

**Dramatically lower attrition of women teachers during their early to mid-careers accounts for a significant portion of the overall attrition decline; we believe that this decline may be largely associated with the changed behavior of women in the labor force.** Our analysis shows that the attrition decline has been much steeper for women than for men. Since women account for approximately two-thirds of all teachers, their steeper attrition rate decline is a significant factor in reducing overall attrition. For men, annual attrition declined from a peak of 10 percent to less than 5 percent. For women, the decline is from a peak of almost 17 percent to almost 5 percent. In earlier years attrition rates of men were significantly below those of women, but by the mid-1980s, the attrition rates of men and women were very similar.

Moreover, our statistical analysis supports the hypothesis that this difference is partly attributable to the changed behavior of women in the labor force. During the 1965–87 time period, the participation rate of women age 25–29 in the full-time workforce changed from 43 percent to 72 percent. This substantial increase in labor-force participation has been triggered by a number of factors: the change in society's attitude toward women working, women's increased preference to work outside the home and their stronger attachment to the labor force, later marriages, which have tended to keep women in the labor force longer, and the need for two incomes to support families. From 1965–84, the median income of men in the 25–29 age group actually fell in real terms by 8 percent. Thus, to maintain and increase family income, women needed to work.

Women teachers appear to have followed the general labor-force trend among women. They dropped out of the teaching force less often to raise children, returned more often, and stayed out for shorter periods of time. This change in attrition would most likely have occurred independent of changes in teacher salary or working conditions and is simply an effect derived from the changing labor-force participation of women. This has affected teacher attrition rates dramatically simply because of the large proportion of women in teaching. Labor-force participation of women is likely permanent, and will prevent teacher attrition rates from ever reaching the high levels encountered in the late 1960s. However, female labor-force participation rates are unlikely to grow much further, making further inroads in attrition from this factor unlikely.

**Two important factors in explaining declines in attrition are the increase in beginning teacher salary levels and the relatively favorable salary growth experience of later cohorts in real terms.** Average beginning teacher salary levels in Indiana declined from a peak of $20,800 (1987 dollars) in 1970 to $15,400 in 1982—a decline of 26 percent. Since 1982, salaries have risen and by 1987, they averaged $17,500, a 14 percent increase. Our analysis shows that attrition rates are responsive to changes in teacher salaries. A 10 percent increase in beginning salaries would reduce annual teacher attrition by 10 percent for men and 4 percent for women.

**Declining average class sizes also have contributed to declining teacher attrition levels.** Our best surrogate for teacher working conditions was average class size. The average class size in Indiana has declined 24 percent from 25.8 in 1965–66 to 19.5 in 1985–86. In recent years, the state has mandated smaller class sizes in lower elementary grades. Our results show that declines in class size will reduce attrition and suggest stronger effects for men than for women. However, we have elsewhere suggested that this gender difference may not be due so much to the relative insensitivity of women to working conditions (an inference in which we do not place much credence) as to our inability with the current data to clearly distinguish between trends in student/teacher ratios and the similar trends in women's labor-force participation.

**Attrition has also declined among cohorts of new teachers because a greater proportion of new teachers are older.** In 1965–66, 75 percent of new, inexperienced teachers were recently out of college and between 22 and 24 years of age, compared with only 40 percent in 1987–88. The proportion of entering teachers age 25–29 years has increased in this same time period from 13 to 33 percent; the over-30 age group has grown from 10 to 27 percent. We find that women teachers who enter teaching at older ages have significantly lower attrition than those who enter shortly after college. By the fifth year after entry, 43 percent of younger teachers have permanently left teaching in Indiana, whereas only 27 percent of teachers entering over 30 have left.

This 60 percent difference in cumulative attrition between the younger and older age groups of entering teachers can probably be attributed to several factors. First, these teachers are likely to have greater stability in their family lives and probably have school-age children, making it less likely that they will leave for family responsibilities. Second, spouse jobs become more stable after age 30, and relocation as a result of a spouse job change is less likely. Third, teachers entering late may be more committed to teaching, having made a decision later in life to pursue teaching. Finally, family income needs grow as children age, making working more important to meet increasing consumption.

Older entering teachers should continue to be a good source of teacher supply because the 30–45 year old age group will be the fastest growing part of the population as the baby boom ages. Thus, this factor should continue to exert a downward push on attrition rates in the foreseeable future.

**Dramatic differences in permanent cohort attrition exist among teaching specialties; secondary school teachers, especially science teachers, have higher attrition rates than elementary teachers.** Physics and chemistry teachers have the highest level of cohort attrition among teachers, followed by biology teachers. This effect remains after controlling for gender and age at entry. After five years of teaching, permanent attrition for elementary teachers is 36 percent, whereas it is 57 percent for physics and chemistry teachers, and 51 percent for biology teachers. The corresponding rates for other types of teachers are 47 percent for English teachers and 41 percent for mathematics teachers.

Higher outside wage opportunities are an important explanation for these patterns. However, it may be only a partial explanation for the higher attrition rates of science teachers with respect to mathematics teachers. Mathematics teachers appear to have equivalent outside wages, but have much lower attrition than science teachers. Another contributing factor for science teachers, but not mathematics teachers, might be the quality of laboratory facilities and equipment, budgets for science supplies, the workload associated with laboratory classes, and the difficulty of handling students in a laboratory environment.[6] Another plausible explanation[7] is that high-paying jobs in business and industry may be available only to those mathematics teachers who teach advanced mathematics courses and not to the majority of teachers teaching algebra, geometry, and remedial math.

A way to summarize the teaching longevity of various types of teachers is to estimate the time in years required until one-half of entering teacher cohorts have left teaching in Indiana permanently. Table S.1 summarizes this for various types of teachers. For physics and chemistry teachers, one-half have permanently left before four years of teaching. Among elementary teachers, the median length of service is 11 years, when we consider permanent attrition. Older teachers stay much longer: Their median survival time is 16 years compared with a little over seven years for those age 20–24 years.

It is not a coincidence that experienced teachers with skills in high demand and with the highest wages in the private sector (science) are

Table S.1

MEDIAN SURVIVAL TIME IN YEARS FOR SELECTED GROUPS

| Selected Group of Teachers | Annual Attrition | Permanent Attrition |
|---|---|---|
| Overall | 3.9 | 8.2 |
| Male | 5.5 | 9.7 |
| Female | 3.5 | 7.6 |
| Age 20–24 years | 3.6 | 7.4 |
| Age 25–29 years | 3.9 | 6.9 |
| Age 30+ years | 11.9 | 15.9 |
| Nondepartmentalized elementary | 4.2 | 10.9 |
| Special education | 3.8 | 8.4 |
| English | 3.0 | 6.3 |
| Mathematics | 4.1 | 6.9 |
| Physics/chemistry | 2.6 | 3.8 |
| Biology | 3.5 | 4.5 |
| Other science | 3.5 | 6.5 |
| Other departmentalized | 3.9 | 6.9 |

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[6] I. R. Weiss and S. E. Boyd, *Where Are They Now: A Follow-Up Study of the 1985–86 Science and Mathematics Teaching Force,* Horizon Research, Inc., Chapel Hill, North Carolina, 1990. This study shows that math and science teachers give somewhat different responses when asked about their main dissatisfaction with teaching. Science teachers rate quality of equipment and facilities and "no time for hands on" instruction as being important dissatisfactions with teaching.

[7] See Murnane et al. (1988), op. cit.

the hardest to keep. One goal of our education system is to train students in those skills demanded by the private sector and to prepare students for high-paying and productive jobs. And yet, because of the high rate of attrition among teachers of these subjects, we have been experiencing the greatest difficulty in meeting this goal. This problem may at least partly be attributed to the fact that teacher pay scales are not differentiated to pay more to teachers with higher outside salary opportunities. To maintain equity among teachers, teacher unions have worked to maintain uniform pay scales, with the inevitable result of higher turnover and probable lower quality of teachers in those specialties for which the private sector pays higher salaries.

Differentiation in teacher salaries to reflect this difference in outside opportunities and relative demand for skills has often been suggested as a means of retaining such teachers.[8] Under such a system, for example, science teachers and other teachers in shortage specialties would receive higher salaries than other teachers with similar years of experience. This could be accomplished by simply starting them higher on the salary scale or having a separate salary scale or additional fixed annual payments. Some school districts have initiated these practices, and the American Federation of Teachers has endorsed the idea of starting teachers in shortage areas higher on the salary scale.[9] This would allow more choice in hiring teachers and perhaps result in better teachers staying longer in teaching. However, the perceived unfairness of such a system and the possible schisms it might create in the teaching force may prove to be too high a cost for these gains.

## CONCLUSIONS

Explaining the pattern of teacher attrition levels from 1965–87 requires that attrition decisions be placed in the context of:

- The career and life-cycle patterns of individuals;
- Normal labor-force behavior in other professions;
- Changing patterns of participation by women in the labor force and the changing age structure of the labor force;

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[8] Differential pay for different skills, specialties, and work quality is the norm in almost all professions in our society.

[9] Murnane and Olsen, op. cit.

- Compensation and working conditions characterizing the profession.

Higher attrition rates and job mobility early in a career are a normal part of labor-force behavior for all occupations and professions. Individuals choose occupations and jobs with limited experience and information and often decide to change occupations, once more experience is gained. Likewise, employers hire individuals with limited information about their performance, and often terminate employment or encourage marginal individuals to seek other jobs once more information on performance is available. Job mobility, attrition, and occupational turbulence are also more frequent at younger ages because of marriage and subsequent relocation, family responsibilities for young children, or returns to schools to seek more education.

Individuals settle more permanently into jobs and occupations in their early thirties, and attrition rates and occupational mobility decline markedly. Family income needs increase and the costs associated with a change in occupation also increase because of the wage premium that accompanies experience. Location-specific human capital in terms of homes, friends, preferred teaching assignments and schools, professional relationships, and promotion opportunities all combine to reduce attrition drastically during the mid-career (age 35–55 years). The lack of portability of teacher pensions also makes interstate job movement costly.

Against this background of life-cycle attrition patterns, teacher attrition trends have been greatly affected by the changing pattern of women's participation in the labor force. Women teachers have followed the general trend among women of strongly increasing full-time participation in the labor force. The usual pattern women tended to follow in the 1960s and early 1970s was that of employment until marriage, then dropping out for child-rearing, and partial return to the labor force when children grew older. These trends have drastically changed in the 1980s. Women drop out of the labor force less frequently when they marry or during early child-rearing years, return earlier if they leave, and remain more or less permanently when they return. Overall attrition in the teaching profession has been affected more than that of other occupations because two-thirds of all teachers are women. Our analysis shows that reductions in the attrition of women teachers followed similar trends among college-educated women in labor-force participation trends. This trend has accounted for a significant part of the reduction in teacher attrition.

Another demographic trend that has also contributed to reducing teacher attrition is that a greater proportion of entering teachers are older, and older entering teachers have much lower attrition rates than those entering after college. This trend is partly due to the large demographic bulge in the 30–45 age group, which should continue to produce large numbers of later-entering women teachers.

Finally, our analysis shows that teacher compensation and working conditions significantly affect attrition. Further research can help produce better and more robust measures of these effects and can identify the types of teachers most affected by changes in pay and working conditions.

The outlook for future trends in teacher attrition is mixed. In the shorter term—the next 10 years—teacher attrition rates should remain low by historical standards, provided pay levels are maintained in real terms. The other factors that have strongly influenced attrition rates in the downward direction should continue to do so. These include the presence of a predominantly mid- to late-career teaching force, strong labor-force participation for women, increased proportions of newly entering, older teachers, and declining class sizes. In the longer term, teacher attrition rates will be gradually pushed up as the large group of mid- to late-career teachers moves toward retirement, and more younger teachers are hired as replacements. However, since the average age of the current teaching force is just over 40, and retirement usually occurs between 60 and 65, this effect should be at least 10 to 20 years in the future. However, enhanced early retirement benefits could produce earlier effects, and these need to be studied carefully.

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# I. INTRODUCTION

## RATIONALE FOR STUDY

The last several years have been characterized by considerable uncertainty regarding the likelihood and magnitude of a teacher shortage. Some publications have described a potential shortage of teachers during the period 1985–2000 (Darling-Hammond, 1984; and NCES, 1985). The most important cause cited is the upturn in the number of children born during the late 1970s and 1980s—the so-called baby boomlet. Other trends that have been cited in support of this argument are the higher predicted level of teacher retirements over the next 15 years, the declining number of college students majoring in education since the 1970s, a trend toward more stringent teacher certification standards in some states, the continuing move toward smaller class sizes, and the movement of women into other, higher-paying professions.

However, other trends apparently run counter to these and one recent report takes a more optimistic view (Hecker, 1986). High school and junior high enrollment will still be decreasing for several years. The female, college-educated, labor pool, 30–45 years of age—a pool that provides many returning teachers—will be increasing rapidly in this period. In addition, the number of individuals choosing education as a major and the number willing to teach have historically evidenced strong—but delayed—responsiveness to demand conditions. Teacher salaries also appear to be moving upward—another sign of market responsiveness. In addition, some states appear to be relaxing certification standards or implementing nontraditional teacher preparation programs that attempt to attract new recruits into teaching by considerably reducing the costs of entry. This is particularly true for certain subject areas such as science and mathematics, although the efficacy of these policy initiatives in resolving current and potential shortages is still very much in question (Darling-Hammond, Hudson, and Kirby, 1989).

Accurately predicting supply and demand for teachers requires quantitative research and development of models of the historical components of teacher supply and demand, and the development of an integrating model that combines all components within a consistent framework. These separate components have been identified in a previous report that outlined the characteristics of an integrative model (Haagstrom, Darling-Hammond, and Grissmer, 1988). For teacher supply, the historical components include newly graduating, inexperienced teachers, later entering inexperienced teachers, returning experienced teachers, and migrating teachers. For teacher demand, teacher attrition rates are the most important component (Grissmer and Kirby, 1987). Changing enrollments and student/teacher ratios also affect the demand for teachers.

Unfortunately, no adequate national historical data exist on which to base such models. However, several states do have the data required to examine these components. Although we focus on Indiana and Indiana teachers, the study will also improve our understanding of potential national-level shortages as well. National estimates have generally been based on sparse data and simplistic models of supply and demand. These simplistic models, using inadequate information about the sources of teacher supply and the factors important in predicting teacher attrition, have predicted severe shortages at both the state and national levels.

State-level analyses can help national estimates in two ways. First, they can help develop prototypes of supply and demand models and highlight the level of complexity required to produce credible estimates. As such, they can reveal the pitfalls of relying on more simplistic models. Second, state models can identify the critical factors influencing changes in components of supply and demand and also whether these are peculiar to states or are national trends. If the latter, then these can be incorporated into national-level analyses to produce improved national estimates of the components of teacher supply and demand.

Among specific questions that we address in this and companion reports are:

- Are teachers leaving the profession at growing rates?
- What roles do compensation and working conditions play in retaining teachers within the profession?
- Are shortages of teachers likely, and for which kinds of teachers are shortages more likely?
- Are more attractive job opportunities increasing attrition rates for women teachers?
- What types of teachers stay longest in the profession?
- How do attrition rates differ by subject taught?

To fully address the issue of shortages, this research must provide credible explanations for the historical trends we see in each component of teacher supply and demand to produce good forecasts. The longer the time period for which we have historical data, the more credible the explanations for previous trends.

However, most states did not begin to collect data until the late 1970s or early 1980s. A few states have data beginning in the early 1970s. Among states currently being analyzed, only Indiana has teacher data from as early as 1964. This long history has several advantages when estimating supply and demand components. These include:

- Real teacher salaries were higher in the 1960s than at any other time over the last 30 years; thus, analyses of these data should provide more credible explanations of salary effects;
- This time period also saw periods of relatively high teacher demand (the late 1960s) as well as low teacher demand (late 1970s and early 1980s); therefore, we can avoid the bias that results from estimating over periods that may be demand-constrained;
- Class sizes were very large in the 1960s and fell continuously thereafter; we thus have a wide range of variation in this variable that allows us to estimate its effect;
- This time period evidenced dramatic changes in the labor-force participation of women and societal attitudes toward such participation; our data allow us to measure how this affected the attrition of women teachers.

Thus, the data from Indiana provide a comprehensive and powerful base on which to build models of the individual components of teacher supply and demand, and to test the validity of an integrative model.

This is the third of several reports using Indiana data. It examines the most important component of teacher demand—teacher attrition. One companion report addresses teacher supply (Kirby et al., 1991) and another examines the Beginning Teacher Internship Program in Indiana (Hudson et al., 1991). A final report will describe the results from an integrated model of teacher supply and demand that will be used to address questions of possible teacher shortages. These reports, along with the pioneering research done by Murnane and colleagues in the last five years with Michigan and North Carolina data, attempt to fill some of the gaps regarding teacher attrition trends, teachers' career paths, the length of time they stay in teaching, and their patterns of attrition and return to teaching.

## IMPORTANCE OF MEASURING AND MONITORING TEACHER ATTRITION

Accurate measures of teacher attrition are needed to serve several important planning and policy objectives. First, attrition rates largely determine how many teachers need to be hired each year; thus they play a significant role in our attempts to assess future teacher shortages. Because of this, it is crucial to measure and predict attrition accurately. Predicting attrition is not only the most important, it is the most difficult of the components of supply and demand. Without credible predictions of attrition, the potential for teacher shortages cannot be assessed. Such predictions are difficult because of the rapid changes that have occurred in teacher attrition rates over time and the existence of multiple and changing factors that affect teacher attrition rates.

Second, attrition rates—when accurately measured and interpreted—can provide good indicators of the relative adequacy of compensation levels and working conditions within the profession.

Third, differential patterns of attrition across subjects may point to the inadequacy of a uniform system of compensation such as characterizes the teacher labor market. Without pay differentials to compensate those with highly marketable skills—such as mathematics and science teachers—we risk having high turnover among these teachers with perhaps a significant deterioration in the quality of teaching in these areas.

## DEFINITIONS OF ATTRITION

Attrition can be measured in several different ways and it is critical to match the appropriate measure with the policy or planning problem.[1] The base against which attrition is measured is always the number of teachers currently in the teaching force (employed full-time in a teaching position in that academic year). The traditional measure of attrition is the proportion of teachers who leave annually, i.e., during or at the end of the school year. We refer to this as annual attrition. However, our data show that between one-quarter and one-third of those who leave in any given year return to Indiana public schools in subsequent years. We thus define a second measure, called permanent attrition, that takes into account these returns. More precisely, annual attrition is the proportion of the teaching force in any given year that leaves during or at the end of that academic year. Permanent attrition, however, accounts for returns by looking at all future years for which we have data to see whether the teachers return to teaching. If they do, they are not counted as leavers in the year that they leave. Teachers are counted as permanent leavers only when they leave teaching and do not return to it during the study time period.[2] Permanent attrition will always be lower than annual attrition, as long as some teachers return to teaching.

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[1] See Grissmer and Kirby (1987) for illustrations of this point.

In addition to defining these two measures of attrition, we also examine the data in two different ways to measure attrition. First, we examine overall and disaggregated attrition rates among the total teaching force. Trends in these estimates, although useful, can be misleading if the composition of the overall teaching force changes over time. Thus in this report we focus primarily on what we refer to as cohort attrition; we examine the attrition patterns of cohorts of newly hired, inexperienced teachers. Most attrition occurs during the first five years of teaching. It is during this critical period that individuals make career decisions to teach or to pursue other occupations. If policies to improve the quality of the teaching profession are to succeed, they must focus on keeping the best teachers during their initial years of teaching.

For these cohorts of teachers, we estimate annual and permanent attrition rates year by year. For example, for the entering cohort of inexperienced teachers in 1965–66, we estimate how many teachers leave temporarily or permanently in each succeeding year through 1988–89. We compare cohort attrition rates for each entering cohort from 1965–66 to 1985–86 and estimate "survival" functions that allow us to measure differences in attrition trends among various groups categorized by gender, age at entry, and primary teaching assignment. Our multivariate models allow us to analyze how attrition is affected by changes in beginning teacher compensation, outside wage opportunities, labor-force participation rates, and student-teacher ratios (this latter variable acts as a proxy for changes in working conditions in the profession). All of these measures have changed dramatically between 1965 and 1988, and the long history we have on teacher cohorts allows us to determine the effect of these variables on teacher attrition with some degree of confidence.

Such models need a theoretical framework to guide the selection of variables and the specification of the model structure. We present a life-cycle theory of teacher attrition, based on our earlier work (Grissmer and Kirby, 1987), that attempts to account for both voluntary and involuntary attrition. Because teachers leave for a variety of reasons—other jobs, marriage and child-rearing, leisure pursuits, and additional schooling—the theory of teacher attrition needs to consider the effects of imperfect information during job search and to draw from economic theories of human capital (Becker, 1964; Mincer, 1977) and occupational choice, theories of family formation and women's labor-market participation, theories of individual migration, and recently developed theories of the timing of retirement decisions.

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[2] Notice that this measure will be biased upward for later cohorts because these teachers have not had as long as those in earlier cohorts to return (or not) to teaching.

## ORGANIZATION OF THE REPORT

The next section presents a theory of attrition and a review of the empirical literature with special emphasis on articles using survival analysis techniques similar to those we use in this report. Section III presents a profile of the teaching force in Indiana and some trends in annual and permanent attrition for the entire teaching force. We then analyze cohort attrition. We present cohort survival rates for different types of teachers in Sec. IV. Section V reports the results of multivariate analyses of teacher cohort attrition. Conclusions and policy implications are summarized in Sec. VI.

# II. A THEORY OF TEACHER ATTRITION

The original commitment between a teacher and a school district regarding a teaching position is predicated on prevailing information and circumstances. The key to understanding teacher attrition is to recognize that an unforeseen change has occurred that causes a reversal of the original decision.

The theory we present here encompasses attrition over the entire teaching life cycle and attempts to include the role of imperfect information at entry as an important determinant in teacher attrition.[1] Before presenting the theory, we need to delineate what constitutes attrition.

## DEFINITIONS OF TEACHER ATTRITION

Teacher attrition is a deceptively simple concept that does not lend itself to a precise, empirical definition. It is important to recognize that there is no *single* appropriate definition of teacher attrition. Indeed, one cannot define teacher attrition until one defines the policy or research context in which a particular definition will be used.

From a national viewpoint, local attrition that leads to teaching in another school or district is less disturbing than attrition to other occupations. So national policymakers need a definition of attrition that separates those leaving the profession from those who move across districts or states.

At the state and local level, attrition out of a state or district is of concern, since these leaving teachers need replacement. To the local or state administrator, the fact that a teacher continues teaching outside the state or district provides little comfort. The picture becomes even more complicated when looked at from the point of view of the personnel and salary administrators in each district. These individuals need to be concerned with not only how many are leaving but *who* are leaving and for what reasons—whether because of dissatisfaction with salaries and the teaching profession or because of spouse mobility, homemaking, etc.

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[1] The theory presented here is excerpted from Grissmer and Kirby (1987).

In this report we adopt the viewpoint of the state, using the term annual attrition to mean those who leave teaching for some period of time (at least a year).

## VOLUNTARY TEACHER ATTRITION

We need to meld together several branches of literature in developing a theory of voluntary teacher attrition.

### A Human Capital Approach to Teacher Attrition

The fundamental tenet of the human capital theory of occupational choice is that individuals or households make systematic assessments of the likely net monetary and nonmonetary benefits from different occupations and make systematic decisions throughout their careers to enter, stay, or leave an occupation. The monetary benefits include the stream of likely income resulting from entry into a given profession, likely promotion opportunities as well as the value of benefits: health and life insurance, retirement pensions, and so forth. Benefits must also include aspects of job security—the likelihood of steady employment and periods of unemployment—as well as the opportunity costs of a given occupation. The latter concept refers to the ease of transferring to other occupations either voluntarily or if unemployment occurs.

The nonmonetary benefits within an occupation include working conditions, support of coworkers, compatibility of hours and schedules with family and leisure needs, availability of adequate materials and equipment, and in the teaching profession, such factors as the learning attitude of students.

In addition to the likely stream of income and benefits of each occupation, an important aspect of any occupational decision is the cost of preparing for an occupation or the costs of retraining for another one. These costs must include the costs of schooling (tuition and living expenses while in school) and forgone earnings during schooling and while learning a new occupation. Forgone earnings usually form a significant part of the schooling costs.

In simple terms this theory states that individuals will choose to enter occupations or change occupations to maximize the net returns, taking account of both costs of training and stream of benefits—properly discounted.

The theory further posits that as an individual stays in a profession, he/she accumulates occupation-specific human capital which translates into wage premiums that are available as long as the individual works within that occupation. This occupation-specific capital arises from contacts and networks that make jobs and promotions easier, from specialized knowledge within an occupation, and from other factors. This occupation-specific human capital forms a barrier to leaving the occupation, since its absence in another chosen occupation would lead to lower wages. This helps explain why occupation switching is more prevalent during the early phases of a career as opposed to later.

A third aspect of human capital theory is also important for teaching—human capital that is location-specific. Such location-specific human capital can include home ownership, knowledge about locales, spouse jobs, closeness to friends and families, and knowledge and contacts for summer and alternative employment. It is another reason why movement is more likely early in a career rather than in mid-career—since more location-specific capital (such as home ownership) is accumulated with age.

A final aspect of human capital is called firm-specific—and in the case of teaching could be associated with particular schools, school districts, or state systems. This capital refers to factors not transferable to other schools or school districts and its presence serves to deter moving from a school or school district. Examples are institutional/organizational knowledge of school practices and programs acquired over the years, seniority/status in the system, and so on. Among these, perhaps one of the most important factors is the retirement benefits accruing to teachers. Teacher retirement systems are either local or state-based. Moves out of the local school system or out of the state would mean that retirement benefits could not be transferred to the new job. Individuals with a number of years of vesting would have a great deal to lose by moving or separating and would be increasingly reluctant to leave. Thus, mid-career and late-career teachers will tend to have extremely low levels of attrition, particularly as the years of vesting and present value of expected retirement benefits increase over time (Viscusi, 1985).

The theory of human capital basically posits that—other things equal—the greater the amount of occupation-specific, location-specific, and firm-specific human capital that accumulates, the lower will be the probability of attrition. An alternative statement of this hypothesis is that the higher the accumulation of these types of human capital, the higher the alternative wages required to induce teachers to leave teaching. Generally, individuals accumulate these kinds of human capital with years of experience within the profession or at a particular location or a particular school. Thus leaving a profession, location, or specific school is more likely earlier in the career.

The previous discussion dealt with occupation-specific human capital that deters a change of profession. However, building occupation-specific human capital in teaching can also ease transition into a set of jobs that can be broadly defined as within the education career field. This "stepping stone" theory of transition out of the classroom involves a set of jobs for which having teaching experience is an asset if not a requirement. Thus, entry into school administration or school psychology and counseling or becoming a college professor of education (all of which generally constitute permanent attrition) might require and benefit from elementary or secondary school teaching experience. Teaching experience might also be an asset in entering human service professions, which span a spectrum from social work and psychology to certain types of law. Teaching can also serve as a way to accumulate savings to support graduate or professional school. Teaching can also provide a job while one's preferences for future jobs are sorted through. For these individuals, attrition from teaching is often a planned and sought-after transition.

This notion of teaching as a stepping stone may be particularly important in explaining attrition of teachers of higher ability. These teachers would be the most likely to enter administration, go to graduate or professional school, or teach at the college level. The timing of exit from teaching will depend on when opportunities arise for graduate or professional education, or when sufficient savings are available, or when specific job opportunities arise in administration.

There is also a more generic form of human capital which is learned in any occupation and can be transferred to another profession. This generic human capital usually is useful in some subset of other occupations and generally defines what occupational transfers are likely. For instance, science and math teachers might be considered to possess a set of skills and knowledge more easily transferred to other noneducational, potentially more lucrative jobs.

Although the theory of human capital provides one explanation for the wide variance between early- and mid-career attrition, there is an alternative (although not necessarily a competing) explanation. A major limitation of human capital theory is its assumption that an individual has perfect information about salary, benefits, and the nonpecuniary aspects of different occupations and jobs. In reality each calculation involves a great deal of uncertainty. In a world characterized by limited information, such decisions must be made on the basis of very incomplete information. As a result, occupational choices may be subject to change as new information later becomes available through actual labor-market experience. An important reason for attrition can be an unforeseen change in the information available and values after beginning to teach.

## The Role of Uncertainty and Incomplete Information in Teacher Attrition

The process of finding and accepting a job is usually conducted in an environment (like the original occupational choice decision itself) of uncertainty. The worker and the employer both have incomplete knowledge of each other and of other employment alternatives. However, searching for better or more complete information brings with it attendant costs that must be weighed against the benefits provided by the increased information.

We can portray the school and the teacher as entering into the initial teaching contract with limited information about each other because of the costs of further search. Individuals may need to decide on employment before all offers are available. Districts may make offers before all candidates are interviewed. At the time of the offer, however, both parties may consider a specific job to be in their own best interests, based on an assessment of perceived present costs and benefits.[2] For example, for the school, the benefits of an employment offer would include the possibility of having the vacancy filled and the resulting contribution to overall productivity; these would have to be weighed against the risks of not having the vacancy filled and the costs of further search for a replacement candidate. From the individual's point of view, the calculus includes the benefits of accepting employment versus the costs of waiting and searching for a better job and, perhaps, risking not being employed for a period of time.

Early attrition can be explained as resulting from either (a) a reevaluation of the costs and benefits of the current job versus alternatives based on newly acquired information about the current job, or (b) a change in the set of alternative opportunities available at the time the original job decision was made, or (c) some combination of both sets of factors.

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[2] For further discussion of costs and benefits in selection decisions, see Wise et al. (1987).

The recent literature in labor-market theory attempts to explain quitting behavior in terms of the original uncertainty and imperfect information available at the time of job acceptance. Such models can be classified into two categories according to their characterization of the source of that uncertainty.

The first model of quitting behavior (Lippman and McCall, 1979), a search model, depicts the worker as selecting a job without completely searching all alternative jobs because of high search costs. New information on alternatives after job acceptance leads to a reappraisal of the job match. For instance, a higher wage offer on an alternative job may occur after acceptance of one job.

In addition, information regarding the prospects and attractiveness of relevant alternative occupations is also likely to be received and reevaluated on a continuing basis. Critical parameters in whether alternative offers are sought and whether they will be judged superior are salaries and working conditions. This will be particularly true for individuals with training and skills that are more easily transferred to other occupations or are particularly valued in general (for example, degrees in mathematics and sciences are easily fungible across sectors and probably better rewarded, at least in a monetary sense, in other sectors). Alternative offers may also be more likely in times of economic growth and declining unemployment than during times of economic stagnation and rising unemployment.

The second model, based on Nelson's (1970) approach to consumer behavior in product markets, assumes the existence of unobservable characteristics of a job that can be learned only through experience on the job.

In these experience models, then, jobs have two classes of attributes: inspection (or search) characteristics, which can be observed directly or without actually experiencing the job, and specific (or experience) characteristics, which become evident only through actual experience. The acceptance of any job is conditional; if the jobholder finds the value of the experience attribute (about which he was imperfectly informed) below some critical level, he will quit.

These models can be easily extended to include separations initiated by the employer (involuntary attrition as a result of performance), by positing two types of employee attributes: screening attributes, which can be observed by the employer before employment (say during interviews, certification procedures, or competency tests), and performance attributes, observed by the employer only after the individual works on the job. The attrition process can then be viewed as the consequence of rational decisionmaking in which belated information regarding the various experience attributes of the job by the teacher and the performance attributes of the employee by the employer is received and reevaluated by both.

One theory posits that the greater the amount of experience attributes or performance attributes present in a given employment contract, the more likely attrition will occur. This theory helps explain why newly graduated teachers are more likely to leave teaching than teachers who are returning to the workforce.

In addition to the uncertainty and incomplete information about other job prospects and the uncertainty involved in the actual job choice, several life-cycle-specific factors that change alternatives open to teachers—such as marriage, birth of children, and relocation—can determine the timing and occurrence of a job separation.

### Changes in Family Status or Residence After Job Acceptance

The initial decision to accept a specific job is conditioned on the existing family status and choice of residential location. However, a change in either of these will cause the individual to reevaluate the initial decision in the light of these new circumstances. The likelihood of changes in family status or residence tends to be fairly high for individuals in the early career stage. Teachers are likely to enter the labor force single but have a high likelihood of experiencing marriage, birth of children, and relocation during their initial years of teaching. These changes often involve either attrition from a district or from the profession.

We have seen that voluntary attrition is more likely to occur early in the teaching career. Below we will see that involuntary attrition is probably more likely for younger teachers as well.

## INVOLUNTARY TEACHER ATTRITION

Involuntary attrition can be caused by poor performance, reductions in force, and other reasons. The latter category can include mandatory retirement, death, and illness. Two reasons explain discharge decisions on the part of the school system. The school in hiring a teacher is subject to much the same sorts of uncertainty and incomplete information as the teacher. Some attributes of the new hire are observable and measurable by inspection through examination of credentials, school grades, and activities, and in the interview process. Other attributes, however, become evident only after the teacher has been in the job for a time period. It is likely that critical values for performance levels may themselves be a function of perceived future shortages or perceived difficulty or ease of replacement. For instance, tighter standards may be enforced if a teacher surplus exists as opposed to a teacher shortage. These standards may also be influenced by the presence of teacher union rules and procedures for terminations and by various apprenticeship programs. However, it is likely that performance will be observed soon after initiation of teaching and most attrition for this cause will be early in the career.

Another cause of involuntary termination is reductions in force. The timing of the RIFs often depends on fiscal circumstances in individual school districts, the pace of school consolidation, and other individual district-specific factors. When RIFs occur they tend to fall more heavily on both younger and older teachers although the mechanisms are very different. Attrition rates for older teachers increase during a RIF because more generous early retirement plans often are available or individuals simply choose to retire earlier. Attrition rates for younger teachers increase because RIFs often are based on seniority.

The final category of involuntary attrition includes mandatory retirement, illness, and death. This type of attrition, of course, would differ by age and perhaps by gender.

## SUMMARY OF VOLUNTARY AND INVOLUNTARY ATTRITION BY CAREER OR LIFE-CYCLE STAGE

The theoretical framework outlined above highlights the fact that *voluntary* attrition decisions depend crucially on six factors:

- The degree of acquired occupation-specific, location-specific, and firm-specific human capital;
- The informed nature of the original job commitment and the nature of the original job search;
- The previous work and teaching experience of the teacher at entry;
- The probability of changes in marital status, family composition, and residential location after employment;
- The salary and working conditions of teachers; and
- The job characteristics and wage levels of alternative opportunities both inside and outside teaching.

*Involuntary* attrition decisions depend on:

- The probability that the performance characteristics of the teacher will not meet some threshold level set by the school district;
- The chance of teacher layoffs, which is primarily influenced by enrollments, fiscal environment, and perhaps union rules;
- Mandatory retirement rules; and
- Illness and death.

## TESTABLE HYPOTHESES

Some of the testable hypotheses deriving from our theory are:

- Annual attrition should follow a U-shaped curve with respect to age: Both the incomplete information theory and the life-cycle theory reinforce this. Attrition rates are likely to be high in the early years of teachers' careers, very low in mid-career, and high again as teachers approach retirement.
- Attrition is likely to be lower among new teacher cohorts with higher proportions of older teachers. Older teachers are likely to have greater family and spouse job stability and to have made more reasoned decisions to enter teaching than those entering at younger ages.
- Whether men are likely to have higher attrition rates than women is difficult to determine a priori: Women tend to have greater child-rearing responsibilities and to be second earners in the family. This would argue for higher attrition among women, relative to men. On the other hand, men are likely to have a much broader set of outside opportunities and so may leave teaching permanently for other professions.
- Teachers of subjects that have greater transferability to other occupations are likely to have higher attrition rates than, say, elementary school teachers. This will be particularly true if the wages offered in business and industry are much higher than teacher salaries. Examples would be teachers of mathematics and science, where the starting salaries tend to be rather high relative to starting teacher salaries.
- Higher salaries should deter attrition. A higher salary increases the relative rewards of staying in teaching compared to other professions. On the other hand, this effect may be

confounded if higher salaries are offered in school districts with difficult working conditions where attrition is likely to be high.

- Working conditions should play an important role in teacher attrition. For example, we expect that smaller class sizes—our proxy for working conditions in the teaching profession—should reduce attrition. Others that are likely to prove important are adequacy of supplies and laboratory materials (particularly for science teachers), respect and support from administrators and peers, good relationships with parents, and student discipline. Unfortunately, these measures are not quantifiable with our data.
- The changing role of women in the labor market is also likely to affect the attrition rates of women. If, as has been true in the 1980s, it has become more acceptable to enter and stay in the labor force, despite marriage and child-rearing, two traditional reasons to leave a job, then we should see a concomitant decline in the rates of women leaving teaching, shorter breaks in service, and higher, permanent rates of return to teaching. There, thus, should be a downward trend in women's attrition. We do not expect the same effect for men, as they have traditionally had high rates of labor-force participation.
- Higher wages in jobs outside of teaching should increase attrition, particularly among those who have skills that are easily transferable to other sectors and whose skills are in high demand by these sectors. Our best proxy for this opportunity cost of teaching is the median income of college graduates employed full-time and we expect that as income goes up, we should see an increase in attrition.

We test these hypotheses in the analyses described in subsequent sections. We turn now to a review of the empirical literature with special emphasis on studies using survival or cohort analyses, similar to the methodology used in this report.

## REVIEW OF THE EMPIRICAL LITERATURE

Studies of teacher attrition (broadly defined for now to include both teacher mobility across school systems as well as separation from teaching) vary considerably in their sample sizes, methodology, and level of sophistication. The literature does not lend itself easily to categorization but the foci of the studies appear to revolve around (a) reported reasons for attrition, (b) determinants of attrition behavior, and (c) survival analyses of teacher cohorts. Clearly, these foci overlap to some degree and equally clearly, some studies address more than one issue.

We provide here a brief overview of some of the principal findings of these studies. For a more detailed review, see Grissmer and Kirby (1987). These findings tend to provide considerable support for the career and life-cycle theory of attrition explicated above.

- Most reported teacher attrition can be accounted for by normal and understandable changes in a person's life and a desire for professional and job advancement. These categories of attrition include return to homemaking or school, retirement, death or illness, or a change in teaching jobs from one district to another triggered by a spouse or family-related move or a search for a higher-paying or otherwise better teaching position. These categories have in the past accounted for approximately 60–75 percent of teacher attrition at the district level. These categories—with the possible exception of retirement—are relatively immune to the effects of educational policy.
- Many teachers who separate from a district will return to teaching. The major reason for leaving a district is to teach elsewhere and the second reason is to withdraw from the labor force either to go to school or for homemaking. Many of those who dropped out of the labor force will return to teaching after finishing school or raising a child. Estimates from historical data show that approximately 40 to 60 percent of teachers who leave districts might return to teaching.
- Attrition rates appear to exhibit a strong U-shaped relationship with age and years of experience with high levels of attrition for young and retirement-eligible teachers (generally around 10–20 percent) and very low attrition rates in mid-career (around 5 percent).
- The attrition curve is U shaped for both men and women teachers, but women tend to have higher early attrition rates than men, nearly equal attrition rates during mid-career, and either the same or slightly higher rates in late career.
- Attrition and mobility are higher among newer teachers. New teachers appear to be more subject to disillusionment, dissatisfaction, changes in family status and residence, as well as discharges due to a combination of new information acquired

> by the school and institutional work rules that determine the hierarchy of layoffs during RIFs. They also are more mobile—typically entering teaching jobs with fewer nonpecuniary advantages and gradually finding their way to schools or districts that have higher pecuniary and nonpecuniary advantages. Once there teachers tend to have much lower attrition and mobility rates.

Earlier studies using survival analysis techniques consist in general of a univariate-type analysis, examining the survival rates over time of different homogeneous subgroups without attempting to fit parametric distributions or to use the multivariate methods more common today.

Whitener (1965) examined turnover rates in 10 Missouri school districts for teacher cohorts of 1951, 1952, and 1953. The approach was refined and extended by Charters (1970) who used it to analyze 1962–63 data from Oregon. Mark and Anderson (1978, 1985) later used the same technique for studying survival rates among teachers in the St. Louis Metropolitan area, from 1969–82. This allowed them to examine several different cohorts and provided a much longer period of observation at least for the earlier cohorts.

The findings from the studies are remarkably consistent. Gender and age (predominantly for women) tend to stand out as prime determinants of survival. The U shape of the attrition curve is also borne out, with attrition being very high during the first five years. For example, Whitener found that only 38 percent of the total cohort survived through five years; however, 75 percent of those who survived remained during the following five years. Charters found that for men, school district size also tended to be important. This latter may be serving as a proxy for salary opportunities and availability of senior administrative jobs. Charters points out in a useful discussion that age itself (except in the case of retirement) is not a force acting directly on separations; instead it reflects underlying physiological, cultural, economic, and social forces that change with age. He stressed the importance of adopting a life-cycle approach when analyzing survival of women teachers.

Mark and Anderson (1978) confirmed the general trend of downward sloping survival curves but found significant differences among cohorts. For example, the proportion surviving beyond one year increased from 64.7 percent for the 1968 cohort to 83.6 percent for the 1973 cohort and this shift upward held through the latter years. There was also evidence to show that the large differential reported by Charters between the survival rates of men and women appeared to be decreasing over time. Their later study was consistent with the earlier study. For each cohort there were rapid decreases in the early years of teaching, with declining percentages dropping out in later years. Differences were again found across cohorts, with maximum survival rates occurring in cohorts who entered teaching in the early 1970s.

Murnane, Singer, and Willett (1988, 1989) use proportional hazards modeling to investigate the relationship between teachers' background characteristics and their career durations, using data from North Carolina and Michigan. They found that the effect of gender on length of first spell (defined as continuous teaching without interruption) differed significantly by entry age with young women tending to have the shortest first spells of teaching. However, many teachers returned—from one-quarter to one-third of teachers who left during the first eight years of teaching returned to teaching with young women having the highest return rate. Chemistry/physics teachers tended to have short first spells as did English teachers; however, the former were also least likely to return to teaching. Their second study explores the relationship between teacher salary and opportunity cost (as proxied by subject specialty and standardized test scores) and the risk of leaving teaching. Separate analyses were conducted for elementary and secondary school teachers. Their findings indicate that among secondary school teachers, (a) chemistry/physics, biology, and English teachers are particularly at risk of leaving teaching within one or two years in the classroom as compared to other specialties; (b) teachers with high scores on the National Teacher Examination (NTE) are more likely to leave teaching sooner and are less likely to return than teachers with low NTE scores—this is true not only for beginning teachers but for experienced teachers as well; and (c) those earning more tend to stay in teaching longer than those earning less, although the importance of this variable as a predictor declines with years of experience. Among elementary teachers, salary tends to have a more modest and a more stable effect over time, but the effects of NTE scores are large, especially in the first years on the job. Elementary teachers are, on the whole, much less likely to leave teaching and are much more likely to return to teaching than secondary school teachers.

Papers by Murnane and Olsen (1989, 1990) provide perhaps the best and most sophisticated econometric analyses of length of stay in teaching. They used a "waiting time" regression technique that has several important and useful properties. This model allows them to accommodate right-censoring (due to incomplete spells) and fixed effects introduced to capture unobserved school district characteristics. However, the model also requires several simplifying assumptions to allow estimation. One example is the assumption that teachers who leave make this decision on the basis of perfect knowledge of future salary levels. For some teachers this requires looking ahead 10 to 15 years. Thus the models may not properly estimate the effects of changing pay levels. Findings from their analyses of Michigan data are:

- Fifty-two percent of teachers beginning in the early 1970s were still teaching in the eleventh year. Approximately one-quarter of the group still teaching had had at least one interruption in teaching.
- Attrition of teachers was much higher in earlier years than later years.
- For those with a career interruption, approximately two-thirds were absent for only a year. Surprisingly, the pattern of career interuptions was similar for men and women. Career interruptions were often accompanied by district changes, with district changes more likely the longer the interruption.
- Cohort survival rates for uninterrupted teaching were much higher for cohorts entering in the late 1970s compared to the early 1970s. Only 45 percent of the latter sample taught for five years compared to 61 percent for the earlier sample, although a higher proportion of the latter sample later returned to teaching.
- Survival rates differed by subject specialty, with chemistry, physics, and foreign language teachers having survival rates of 40 percent through 11 years and elementary, special education, mathematics, social studies, and English having survival rates of 50 percent.
- Chemistry and physics teachers have much lower return rates given an interruption in teaching. Only one-ninth of chemistry and physics teachers still present after 11 years were returnees compared to almost 25 percent for the entire sample.
- Differences among survival rates for different subject specialties were much more marked for the later cohorts.
- Teachers entering the Michigan system were much more likely to stay if they entered at a later age. Teachers entering

at 32 had a 7.5 percent higher probability of staying five years than those entering at age 22.

- Preliminary estimates indicate that salary had a small but statistically significant effect on survival rates for later, but not for earlier, cohorts. The earlier effect was small—a $1,000 salary increment would raise probability of teaching to five years by only 2.7 percent.

The authors point out that the time period for the analysis—a period of rapidly declining enrollment—may make any results not generalizable to other states or time periods. In fact, the large variation in survival rates by cohort shows that teacher layoffs may have had a large impact on teacher survival rates. These results may change during times of expanding enrollments. In addition, the results may be specific to Michigan. Michigan had unusually large enrollment declines in this time period compared to other states. Between 1975 and 1985, enrollments in Michigan dropped by 18.5 percent; the rate was 11.8 percent nationwide. Michigan had strong outmigration trends because of the poor economy in the auto industry. Thus the Michigan experience may not be typical of other states even during this period.

The analysis of the North Carolina data is the most ambitious and relevant attempt to measure pay effects for teachers. These results may be more generalizable than those from Michigan. North Carolina had neither large enrollment declines nor a drastically changing economy that affected tax revenues dramatically. Thus North Carolina may be more typical of other states, especially those with growing populations where shortages are more likely to occur. In addition, NTE test score data were available, allowing for the explicit testing of the effects for different ability in teachers.

The patterns from simple survival data in North Carolina are similar to those found in Michigan. In particular, mathematics teachers in North Carolina also have significantly higher survival rates than physics or chemistry teachers. Using first teaching spell as the primary variable, the results dealing with pay and ability classes include the following:

- Physics and chemistry teachers had the lowest survival rates of all types of teachers, with biology and general science teachers also having lower than average survival rates. Physics and chemistry teachers had predicted continuous ten-year survival rates of approximately 18 percent compared to around 40 percent for all high school teachers. Mathematics teachers, however, had survival rates comparable to or even a little higher than that of the average teacher.

- Controlling for other factors, teachers in the upper quartile of NTE scores leave at significantly higher rates than those in the bottom three quartiles. Continuous survival rates among the lower three quartiles showed much smaller differences although in the same direction. Ten-year continuous survival rates were approximately 31, 37, and 39 for the second, third, and fourth quartiles, respectively.
- Pay increases had a statistically significant effect on attrition and a differential effect on those in the upper and lower quartiles. A $1,000 increase in pay in constant 1987 dollars would increase median duration of the initial stay in teaching by about 2–3 years. However, this effect is much smaller for the later cohorts.
- Pay effects were smaller by about 30 percent for higher-ability teachers compared to teachers with lower ability (as measured by the NTE score).

Some of these results are based on survival analysis similar to that presented here. Others are based on a waiting-time regression model. In general, several different approaches will be required with data from several states before a consistent picture emerges. In addition, the sample sizes for some of the disaggregated groups (for example, physics and chemistry teachers) are rather small, and multiple states are required before larger samples are available.

Our study focuses on Indiana and provides new and supporting evidence on the patterns of attrition among public school teachers. This study differs in that we have data on a much longer time period—24 years—than the period covered in earlier studies. These data are important in that they make the results less sensitive to the peculiarities associated with specific time periods (such as teacher reductions in force) that make generalizability difficult. Our results add to the general body of knowledge of teacher supply and demand and help identify findings that appear to be common to all states and those that seem to be specific to a given state or given time period. The next section describes the data used in this report and presents estimates of annual attrition.

# III. TRENDS IN ATTRITION

This section describes the data, profiles the teaching force over time, and presents some annual attrition rates. We show that a number of teachers return over time and that it is possible and important, therefore, to distinguish annual from longer-term attrition. Because the experience and age of the teaching force change over time, it is often difficult to pinpoint exactly whether overall attrition has changed. For this reason, our remaining analyses focus on "new" teachers—those with no teaching experience. We then track these new teacher cohorts over time and examine their "survival" patterns. These analyses, along with the methodology on which they are based, are described in two subsections.

## DATA

We obtained from the Indiana State Department of Education teacher personnel files containing data on all regular contract employees of the Indiana public school system from 1965 to 1988. These records were linked across years using Social Security Numbers and provide a complete work history (within the Indiana public schools) of teachers over this time period. The records contain a variety of demographic data such as age, sex, educational attainment, and race (although data on ethnicity were not collected before 1978) as well [illegible] teaching-related variables such as years of teaching experience, grade level, subjects taught, and the school district where the individual is teaching. These data are unique in that they span periods of increasing and decreasing enrollments, decreasing student-teacher ratios, high and low teacher demand, and changing roles of women in the labor force. These data allow us to track attrition as well as returns to teaching (at least within the Indiana public school system). We focus here on the total *teaching* force, i.e., those working full-time whose major activity is teaching. Table 3.1 presents the number of teachers meeting these criteria for each year. We find that Indiana's full-time teaching force averages about 50,000 during this time period. As Fig. 3.1 shows, the teaching force increased steadily from 1965–70, then stabilized at around 51,000–52,000 for the next several years. Beginning in 1981, there was a sharp decline in the size of the

## Table 3.1

### PROFILE OF INDIANA TEACHERS, BY SELECTED CHARACTERISTICS AND YEARS

(percent of total)

| Characteristic | Academic Year | | | | |
|---|---|---|---|---|---|
| | 1965–66 | 1970–71 | 1975–76 | 1980–81 | 1985–86 |
| Sex | | | | | |
| Male | 36.1 | 36.5 | 37.6 | 36.2 | 34.2 |
| Female | 63.9 | 63.5 | 62.4 | 63.8 | 65.8 |
| Race | | | | | |
| Nonblack | (a) | (a) | (a) | 94.2 | 94.4 |
| Black | (a) | (a) | (a) | 5.8 | 5.6 |
| Age | | | | | |
| 20–24 | 11.6 | 13.8 | 6.7 | 3.4 | 2.0 |
| 25–29 | 18.8 | 24.3 | 27.8 | 17.5 | 9.5 |
| 30–34 | 11.0 | 12.2 | 17.1 | 22.1 | 15.4 |
| 35–39 | 9.3 | 9 | 11.4 | 16.4 | 22.1 |
| 40–44 | 8.8 | 8.7 | 9.2 | 11.9 | 17.4 |
| 45–49 | 8.8 | 7.9 | 8.5 | 9.2 | 12.1 |
| 50–54 | 9.1 | 7.4 | 7.3 | 8.1 | 9.1 |
| 55 + | 22.6 | 16.8 | 12.1 | 11.4 | 12.3 |
| Years of teaching experience | | | | | |
| 0 | 9.0 | 10.7 | 5.7 | 3.2 | 3.1 |
| 1–4 | 25.6 | 30.3 | 27.9 | 18.7 | 11.2 |
| 5–8 | 15.4 | 15.9 | 21.6 | 21.3 | 15.1 |
| 9–12 | 11.2 | 10.9 | 13.5 | 18.8 | 18.2 |
| 13–16 | 8.9 | 8.4 | 9.5 | 12.6 | 18.3 |
| 17–20 | 7.0 | 6.3 | 7.3 | 9.1 | 12.8 |
| 21–24 | 5.5 | 5.1 | 5.2 | 6.5 | 8.8 |
| 25+ | 17.4 | 12.3 | 9.4 | 9.8 | 12.6 |
| Primary teaching assignment | | | | | |
| Nondepartmental (elementary) | 50.6 | 46.3 | 43.1 | 41.8 | — |
| Special education | 1.6 | 2.4 | 4.4 | 6.9 | — |
| English | 10.5 | 11.2 | 11.2 | 10.8 | — |
| Mathematics | 6.2 | 6.4 | 6.5 | 6.2 | — |
| Physics/chemistry | 1.1 | 0.9 | 0.7 | 0.7 | — |
| Biology | 1.5 | 1.3 | 1.2 | 1.2 | — |
| Other science | 2.5 | 3.1 | 3.5 | 3.4 | — |
| Other departmental | 26.0 | 28.5 | 29.5 | 28.9 | — |
| Grade levels taught | | | | | |
| Elementary (K–6) | 55.7 | 51.4 | 50.7 | 52.0 | 53.9 |
| Junior high (7–9) | 10.9 | 16.8 | 16.7 | 15.4 | 16.6 |
| Senior high (10–12, 7–12) | 33.4 | 31.8 | 32.6 | 32.6 | 29.5 |
| Continuing/returning/new[b] | | | | | |
| Continuing teachers | 85.1 | 82.1 | 90.3 | 92.8 | 92.8 |
| Returning teachers | 6.3 | 7.2 | 4.0 | 4.1 | 4.2 |
| New teachers | 8.5 | 10.6 | 5.6 | 3.1 | 3.0 |
| No. | 43,550 | 51,730 | 52,614 | 52,445 | 50,885 |

[a] Data on ethnicity were not collected until 1978.

[b] Continuing teachers were teaching in the Indiana public school system in the previous year as well. Returning and new teachers were not teaching in the previous year: Returning teachers have some prior teaching experience, new teachers have none.

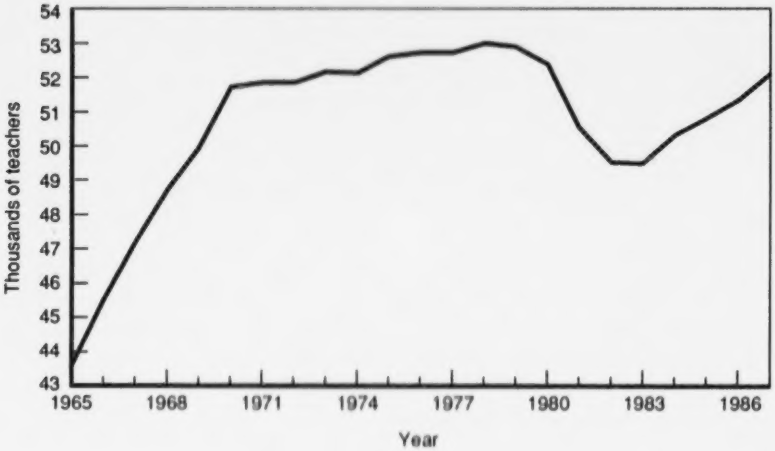

Fig. 3.1—Total teaching force, by year

teaching force, which lasted three years. Since 1984, there has been a small but steady increase and the total force stands today at around 52,000.

## PROFILE OF THE TEACHING FORCE

Table 3.1 presents a profile of the teaching force for selected years by various demographic characteristics. The teaching force consists predominantly of women; a little over a third are men. This is somewhat higher than the proportion of men teachers nationwide. In 1986, for example, 31.2 percent of all teachers were men. Data on ethnicity were collected from 1979 onward. A little under 6 percent of Indiana teachers are black as compared to 6.9 percent of all teachers in 1986.[1] Black representation in the Indiana teaching force seems to be declining: By 1987, the proportion of black teachers had fallen to 5.4 percent. The table shows the gradual aging of the Indiana teacher force. In 1965–66, about 30 percent of teachers were under 30 years of age. By 1985–86, this proportion had fallen to 11.5 percent and by 1987–88, it stood at a little below 11 percent. About 23 percent of Indiana teachers were 55 years old or older in 1965–66. A large number of them retired over the period covered by our analysis and the proportion of those who were close to retirement age in 1985–86 was only about 12 percent. However, it seems clear that the next few years will see a substantial increase in the number of retirement-eligible teachers. This mirrors the general trend in the teacher population nationwide. For example, in 1986, 11 percent of all teachers were 30 years old or younger, down from 34 percent in 1966. Similarly, 26 percent of teachers in 1966 were age 50 or over; the corresponding number for 1986 was 21 percent. The same pattern is evident when one looks at the distribution of teachers by years of teaching experience. Those just entering the teaching profession accounted for about 10 percent of the force in 1965–70. However, this proportion has been falling steadily and in 1985–86, new teachers accounted for only 3 percent of the force. Similarly, the proportion of teachers with one to four years of experience also declined from 25–30 percent in 1965–70 to only 11 percent in 1985–86. These trends continued through 1987–88. The teacher force has increased its level of teaching experience over time, and again this mirrors what has happened to the overall teaching force of the nation.

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[1] Although we refer to teachers as black and nonblack, it should be noted that the group of nonblack teachers includes virtually no other minority groups—it is over 99 percent white.

A little more than half of teachers in Indiana teach at the elementary level. This is somewhat higher than for teachers nationally, among whom about 47 percent were elementary teachers in 1986. The proportion of junior high school teachers has increased over time, remaining steady at about 16 percent since 1970 onward. About a third of the teachers teach at the senior high school level, although this proportion declined a little in the 1980s. The distribution of teachers by primary teaching assignment has remained relatively stable over the last 23 years, with one exception: The proportion of teachers teaching departmentalized subjects and special education increased over this time period. Indeed, there was a fourfold increase in the number of special education teachers from 1965 to 1985.

It is interesting to examine the composition of the teaching force in terms of whether teachers are continuing teachers (defined as teachers who were present last year), returning teachers (defined as teachers with experience who were not teaching in the Indiana public school system last year), or new teachers (teachers who were not present last year and who furthermore have no teaching experience). This distribution has important implications for teacher supply and demand. We find that the proportion of continuing teachers has increased sharply over time, for example, from 85 percent in 1965–66 to almost 93 percent in 1985–86, thus decreasing teacher demand. It is also interesting to find that returning teachers are an important source of supply; indeed, in the 1980s, their proportion exceeded that of new, inexperienced teachers, traditionally thought of as constituting the major source of teacher supply. The fact that teachers are tending to continue in teaching in much higher proportions than was earlier the case suggests that the "reserve pool," the pool of trained, experienced teachers who take a break from teaching and then return to it, may be smaller in the future. Among returning teachers, we attempted to distinguish between those with prior experience in the Indiana public schools and those whose experience was elsewhere (in other states, in parochial schools). We find that about 60 percent of returning teachers have taught before in the Indiana public schools; the remaining two-fifths are "migrating" or "transferring" teachers.

## PATTERNS OF ATTRITION

### Definition of Attrition

In outlining the theoretical framework we had emphasized the importance of defining attrition with respect to a particular policy context and pointed out that one of the simplest and yet potentially the most useful steps in analyzing attrition is to distinguish between what can be termed annual attrition and permanent or longer-term attrition. Annual attrition measures the proportion of the teaching force in any given year that leaves during or at the end of that academic year. This is what we normally mean by attrition or turnover. Permanent attrition, however, looks at all future years for which we have data to see whether those teachers return to teaching. If they do, they are not counted as leavers in that particular year. Teachers are counted as leavers only when they leave teaching and do not return to it during the time period for which we have data.[2] We should make clear that any teacher who leaves a teaching position is regarded as a loss, even if the teacher transfers to an administrative or some other nonteaching position. We contend that these teachers are lost to *teaching*, which is our major focus of interest, regardless of the fact that such positions offer advancement and promotion to such individuals. Thus, we would expect permanent attrition to be lower than annual attrition. Although the weakness in this measure of attrition is apparent—it is, after all, driven by the available data—we nevertheless feel that such a distinction is important and justifiable. It is important because it sheds light on the reserve pool as a source of teacher supply in any given year and justifiable because, as we show below, most teachers return to teaching during the first five years after separation.

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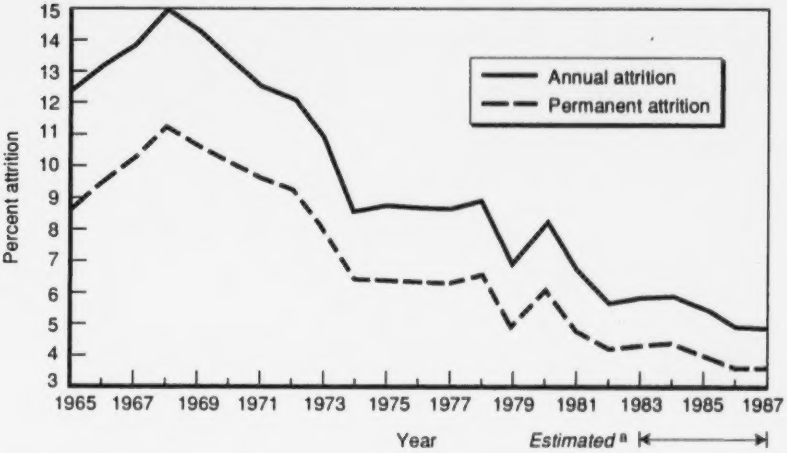
[2] It is evident that we have here adopted the viewpoint of the state. We count as leavers those who do not return to teaching in *Indiana public schools*. We do not have the data to distinguish those who may return to teaching in parochial schools or in other states.

Because we have 23 years of data, we can distinguish annual from permanent attrition fairly easily. Our estimates of the two types of attrition are more accurate for the earlier years than for the last three to four years of data simply because the earlier data track teachers over a much longer time period and teachers who leave have had sufficient time to return. Later groups of leaving teachers (for example, those teaching in 1985–86) have had at the most two years since leaving teaching in 1986–87 to return to teaching. We have not attempted to correct for the bias here because trends in attrition appear to have been changing over time. In addition, in estimating permanent attrition, we have omitted recent cohorts from the sample because of this bias.

Figure 3.2 compares the permanent and annual attrition rates. Among Indiana public school teachers, both rates have fallen markedly over time, mirroring what we saw above regarding the increase in continuation rates over the last 20 years or so. Annual attrition stood at 12–13 percent in the mid-1960s, peaking at 15 percent in 1968. Attrition fell to around 8–9 percent and held steady at this level during 1974–80, falling even further subsequently to around 6 percent. By 1987, the attrition rate stood at 5 percent. We can offer several plausible explanations for this trend. First, the aging of the teaching force is associated with a lower rate of attrition. We had suggested several reasons why this might be true, using a life-cycle theory of attrition. Older teachers tend to have greater geographical, employment, and family stability and to have greater firm-specific and job-specific capital that makes it costly to leave or to change occupations. Second, women's role in the labor market has changed. Over this time period, continuing to work after marriage and during child-rearing has become more accepted and more the norm and women are tending to leave less frequently for these reasons. Also, the economics of family life have changed so that two-earner families



[a] Permanent attrition rates are estimated from 1983–1987 using historical return rates.

**Fig. 3.2—Annual and permanent attrition rates, by year**

have become both the norm and a necessity. Third, as economic conditions changed and teacher demand declined, teachers became less willing to leave whether temporarily or otherwise because of the strong possibility of not being able to return.

It is interesting to note that the pattern of permanent attrition mimics that of annual attrition closely, suggesting that the proportion of teachers who leave in any given year and later return to teaching does not vary a great deal.[3] In fact, we find that this proportion varies from 25 to 30 percent. There appears to be no monotonic relationship between high rates of attrition and high rates of return. For example, in 1968, when attrition was 15 percent, permanent attrition was 11.3 percent, 76 percent of the total; however, in 1979, when attrition was much lower at 7 percent, permanent attrition was just 5 percent, 71 percent of the total. By 1982, the last year probably for which we have captured permanent attrition more or less accurately, permanent attrition was about 74 percent of total attrition. If we assume that a small proportion of teachers in these cohorts return to teaching after the time period for which we have data, permanent attrition would constitute an even smaller proportion of total attrition. It is interesting to note that the later cohorts show a decline in permanent attrition, even given that our measure of permanent attrition is biased upward for these groups.

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[3] We should make clear that we are not suggesting that this proportion is exogenous; on the contrary, we would expect it to be a function of incentives offered, teacher demand, and local economic conditions.

We had mentioned earlier that most teachers return to teaching within five years of separation. This is evidenced by Fig. 3.3, which shows the length of time to return for teachers leaving between 1965–66 and 1982–83. As is clear from the graph, the majority of teachers who eventually return do so within the first year—approximately 48 percent. Another 14 percent return after a two-year separation; the proportion returning in each subsequent year drops fairly sharply after this. About 80 percent of all who subsequently return do so within five years of leaving teaching. We must emphasize that our viewpoint here is that of the Indiana public school system—teachers who return to teaching in other states or in parochial schools are counted as a loss, although from a national perspective, such teachers are still productive. Our data do not allow us to distinguish such teachers from losses; thus, our measure of permanent attrition is a measure of long-term losses to the Indiana public school system. Our measure of an-

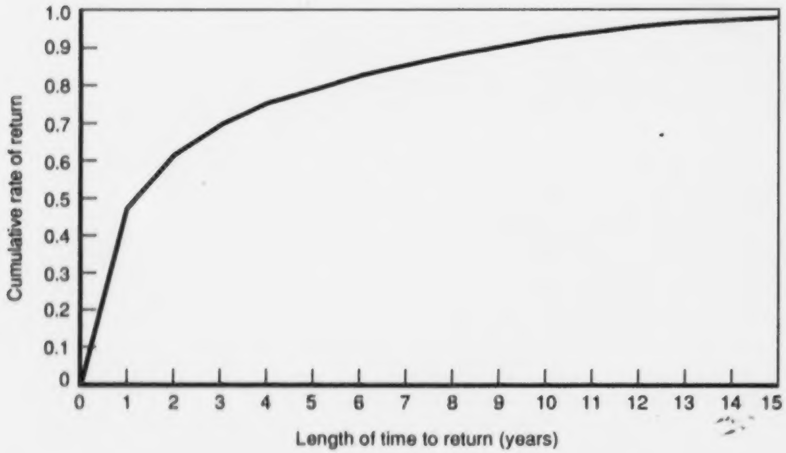


Fig. 3.3—Length of time to return to teaching, 1967–82, all teachers

nual attrition is a measure of turnover from the perspective of local school corporations.

## Patterns of Attrition by Age

Our theory had suggested a U-shaped relationship between age and attrition, with the probability of attrition likely to be much higher during the early stages of the career, very low during mid-career, and high as the teacher approached retirement. This pattern holds true not only over a single cohort but over time as well, with the overall curve moving down to reflect the decrease in annual attrition rates over time. We present annual attrition rates by age of teachers for selected years in Fig. 3.4. Attrition among younger teachers, those aged 20–24 years, tends to be rather high—23 percent in 1965, 13 percent in 1985. Recall that overall attrition for these two years was 12.4 and 5.6 percent, respectively. Thus, attrition for young teachers appears to be almost double the attrition rate for all teachers. The attrition rate falls with age, being the lowest for teachers aged 45–54 years. For these teachers, attrition appears to be between 2 and 4 percent. Attrition, not unexpectedly, is higher (10–17 percent, depending on the year being examined) for those aged 55 and over, who are approaching retirement.

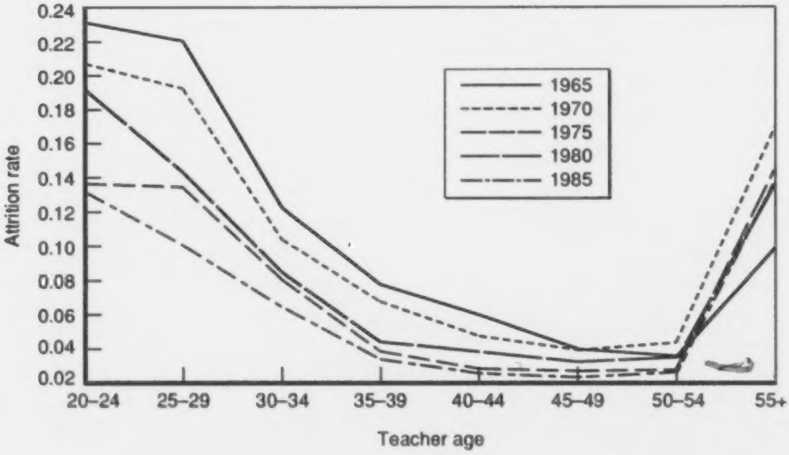
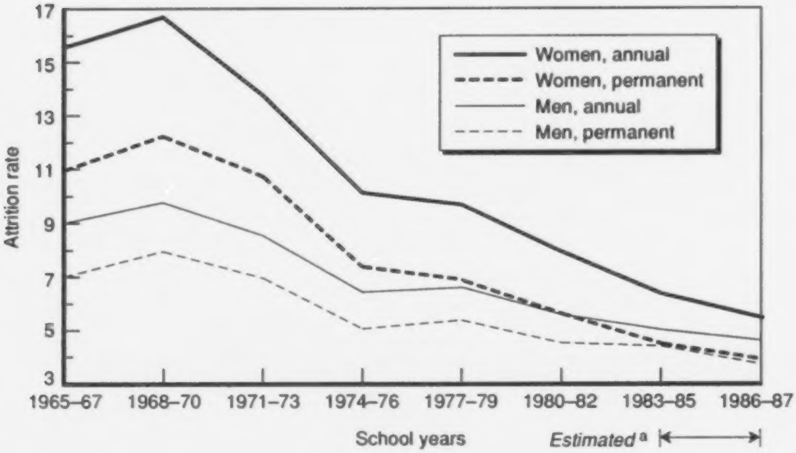


Fig. 3.4—Annual attrition, by teacher age

In comparing permanent with annual attrition among the various age groups, we find that younger teachers tend to return much less frequently than teachers in their thirties; this is, of course, also true of much older teachers who leave teaching because of retirement. Among younger teachers, about 30 percent later return; thus, the permanent attrition rate is approximately 70 percent of annual attrition. Teachers aged 30–34 years tend to have the highest likelihood of returning; their permanent attrition rate is only about 65 percent of their annual attrition rate. The difference may reflect partly the difference in geographical mobility of the two groups. Thereafter, the likelihood of return decreases with age—recall that the attrition rate among those aged 40–54 is very low, suggesting that those leaving may do so because of illness or some other reason that precludes returning to teaching. For those 55 and over, almost all attrition is permanent.

## Patterns of Attrition by Gender

This subsection examines the differences in attrition between males and females across various years. Although the overall patterns over time of attrition of the two groups are surprisingly similar, there has been a substantial change in the overall attrition rate of women. Figure 3.5 shows annual and permanent attrition for men and women. To keep the graph readable, we have combined the teaching cohorts into three-year groups (with the exception of the last two years of data). Annual attrition among women was very high in the late 1960s and early 1970s, averaging 14–16 percent per year. Male attrition, on the other hand, stood at around 8–10 percent. By 1974–76, the female attrition rate had fallen to around 10 percent and has been falling ever since. By the early 1980s, it was as low as 8 percent; by 1986–87, it was a little under 5.5 percent. Male attrition has also fallen over this time period, but certainly not to the same extent as that evidenced by the female attrition rate. For example, in the mid to late 1970s, it stood at around 6.5 percent; by 1986–87, it was 4.5 percent. Thus, female annual attrition, which used to be about 50 to 70 percent higher than male attrition, now is only 20 percent higher. We had, in our theoretical framework, suggested several reasons why women might leave the labor force at higher rates than men, the responsibilities of marriage and child-rearing perhaps being the primary one. However, the role of women in the



[a] Permanent attrition rates are estimated from 1983–1987 using historical return rates.

Fig. 3.5—Annual and permanent attrition, by gender

labor market has been changing. Families have become more dependent on two incomes to meet household expenses, and it has become much more accepted that women stay in the labor force despite child-bearing and child-rearing. These trends help partly explain the large decline in female attrition over this time period. Another explanation is that the teaching force has become much older, and that itself has brought more job, geographical, and family stability, reducing attrition.

It is interesting to note that the differences in the permanent attrition rates of men and women are not as large as those evident above when looking at annual attrition. This suggests that although women tend to leave teaching at higher rates than men, they also return to teaching at higher rates than men. For example, during 1965–67, the difference in annual attrition between the two groups was around 72 percent; the corresponding difference in permanent attrition was only 57 percent. Similarly, although the overall annual attrition rate of women was 46 percent higher than that of men during 1980–82, the difference in permanent attrition was much smaller, only 24 percent. This result is again not too surprising. Men tend to have a larger range of outside opportunities and perhaps greater flexibility in selection—thus, once they leave teaching, it is generally for nonteaching jobs and they have a much lower likelihood of return.

Examining annual attrition rates is informative but limited. These rates let us know what proportion of different kinds of teachers we need to replace in the school system, but comparisons over time can be a little misleading unless we adequately account for changes in the composition of the teaching force. We cannot sort out adequately the effect of changing economic conditions, changing demand, and other unmeasured characteristics that may be present when we group together teachers who entered at different times and under different conditions. To do so, we need to use survival analysis techniques, where we track incoming cohorts of new teachers (those with no prior teaching experience) and examine their experience over time. These techniques provide methodologically simpler and more credible measures of duration as well as of the differences in duration by selected demographic and economic factors. We turn to these results in the following two sections.

# IV. PATTERNS OF ATTRITION AMONG NEW TEACHER COHORTS

## DATA

The data for this analysis consist of cohorts of new teachers from 1965–86. For any given year, new teachers were defined as those who had never before taught in the Indiana public school system and who had no prior teaching experience. Figure 4.1 shows the size of the new teacher cohorts over time. It is clear that these varied considerably, with the largest number of new teachers being hired during 1967–71, when the number reached 4,500 and over. Indeed, in 1970, 5,500 were hired. Since then, the size of the cohorts has declined steadily, reaching an all-time low during the early 1980s of around 1,000. Since 1984, the number has stabilized at around 1,500 new teachers per year. Not only has the actual size of the cohorts declined over time, but the proportion of new teachers in the overall teaching population has decreased as well.

Demand for new hires can be filled either through hiring new, inexperienced teachers or experienced teachers, who are returning to

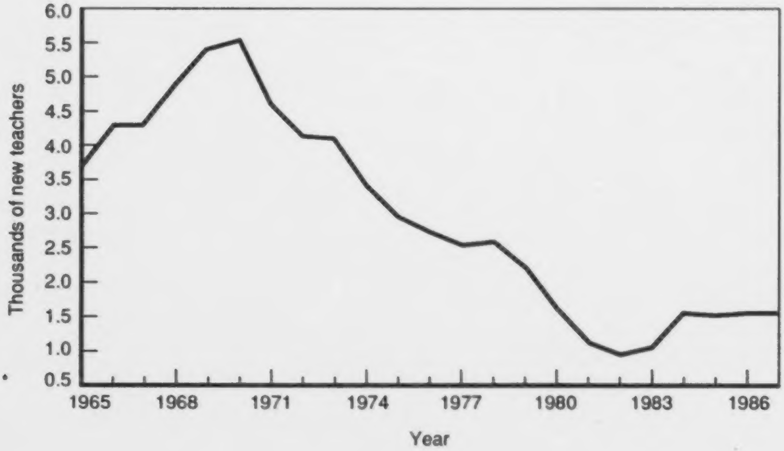


**Fig. 4.1—Total number of new teachers, by year**

the workforce after a break in service or are tranferring from other states or parochial schools. It is interesting to compare the relative proportions of these two types of new hires over time, as shown in Fig. 4.2. During the late 1960s and early 1970s, new teachers accounted for about 9–10 percent of all teachers. By mid-1970, this proportion had fallen to around 5 percent and by 1980, it stood at 3 percent. During 1981–83, new teachers formed barely 2 percent of the overall teaching force; the proportion stands at 3 percent today. This decline is partly a function of the steady decline in attrition rates of the overall teaching force and partly because the demand for new hires has been traditionally filled at least partly by hiring experienced teachers (returning Indiana teachers, those transferring from other states or parochical schools). Where formerly experienced new hires were a smaller proportion relative to new teacher hires, the reverse is now true. From 1984 onward, the number of experienced new hires has remained remarkably steady at around 4 percent of the teaching force. However, the increase in continuation rates suggests that the experienced teacher reserve pool may shrink over time (unless strong measures are taken to hire teachers from out of state or from parochial schools). If so, we can expect the new teacher cohorts to start increasing in size eventually.

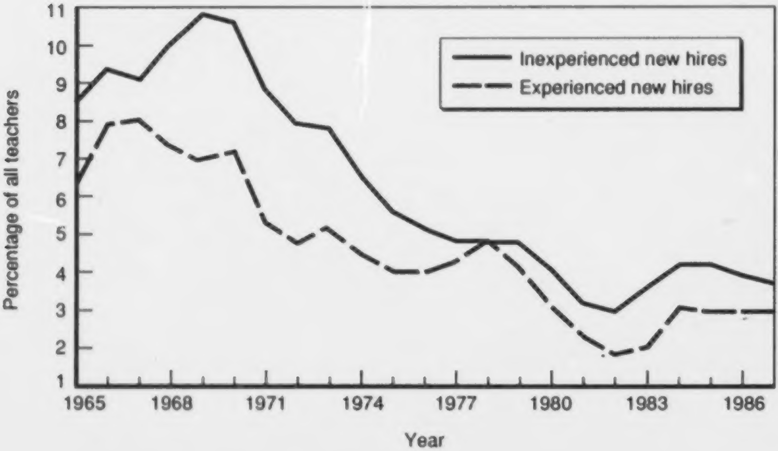


Fig. 4.2—New hires as a percentage of all teachers, by year

Table 4.1 presents a profile of the new teacher cohorts for selected years. The proportion of men among new teachers has been declining since the mid-1970s and since 1985, only a quarter of the new teachers are men. Black representation in the new teacher cohorts is also smaller than in the total teaching population—between 3 and 4 percent and in some years being even lower than that. In 1987, new black teachers accounted for 3.9 percent of all new teachers.

Not unexpectedly, most new teachers are young, 20–24 years of age, and are presumably new college graduates. There is a somewhat surprising trend over time, however; new teachers are tending to be older than was the case previously. For example, generally three-quarters of new teachers during the 1960s and 1970s were younger than 25. By 1985, fewer than half were in this age range, with almost a third being between 25 and 29. This suggests that new graduates are postponing entering teaching, perhaps to stay in school longer or to try other occupations. Indeed, by 1987, about 27 percent of all new teachers were 30 years old or older.

New teachers tend to be predominantly elementary school teachers, although the proportion teaching nondepartmentalized elementary subjects has decreased over time. The primary reason for this appears to be the large increase in the number of special education teachers. Other than this, the distribution of new teachers by primary subject area appears to reflect the overall distribution of teachers. This is true for the grade-level distribution as well.

We now turn to a description of the methodology used in analyzing the career paths of these new incoming teacher cohorts.

## METHODS OF ANALYSIS[1]

A distinguishing feature of our data, and most time-to-event data, is that the event, in our case attrition, may not have occurred at the time of analysis. We do not observe attrition for individuals who have not separated from teaching by 1988, although some of them may later leave teaching. These data are "right-censored"; we know only the amount of time that elapsed between the time the individual entered teaching and the beginning of academic year 1988 and that the individual had not left teaching by then. Special techniques have been developed to handle censored data and we use two of these techniques in our study.

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[1] This is adapted from Marquis and Kirby (1989) and from Murnane, Singer, and Willett (1988).

### Table 4.1

### PROFILE OF NEW INEXPERIENCED TEACHERS, BY SELECTED CHARACTERISTICS AND YEARS

(percent of total)

| Characteristic | Academic Year 1965–66 | 1970–71 | 1975–76 | 1980–81 | 1985–86 |
|---|---|---|---|---|---|
| Sex | | | | | |
| Male | 30.4 | 28.4 | 31.8 | 29.6 | 27.0 |
| Female | 69.6 | 71.6 | 68.2 | 70.4 | 73.0 |
| Race | | | | | |
| Nonblack | (a) | (a) | (a) | 95.9 | 97.0 |
| Black | (a) | (a) | (a) | 4.1 | 3.0 |
| Age | | | | | |
| 20–24 | 74.6 | 74.8 | 64.3 | 59.9 | 42.8 |
| 25–29 | 14.6 | 15.7 | 26.9 | 27.0 | 34.4 |
| 30–34 | 3.1 | 3.1 | 3.2 | 6.9 | 10.1 |
| 35–39 | 2.9 | 2.6 | 2.6 | 2.7 | 7.4 |
| 40–44 | 2.6 | 2.0 | 1.4 | 2.1 | 3.7 |
| 45–49 | 1.4 | 1.1 | 0.8 | 0.6 | 0.9 |
| 50–54 | 0.5 | 0.5 | 0.5 | 0.4 | 0.3 |
| 55+ | 0.3 | 0.2 | 0.2 | 0.4 | 0.3 |
| Primary teaching assignment | | | | | |
| Nondepartmental (elementary) | 48.2 | 49.2 | 36.7 | 31.4 | — |
| Special education | 1.8 | 3.3 | 11.9 | 19.3 | — |
| English | 13.6 | 11.4 | 11.3 | 9.8 | — |
| Mathematics | 5.8 | 5.5 | 7.1 | 5.8 | — |
| Physics/chemistry | 0.7 | 0.4 | 0.3 | 0.6 | — |
| Biology | 1.0 | 0.6 | 0.7 | 0.6 | — |
| Other science | 2.8 | 3.1 | 3.4 | 4.1 | — |
| Other departmental | 26.2 | 26.5 | 28.6 | 28.3 | — |
| Grade levels taught | | | | | |
| Elementary (K–6) | 53.3 | 55.0 | 52.8 | 54.0 | 57.4 |
| Junior high (7–9) | 12.7 | 17.0 | 16.1 | 12.2 | 14.5 |
| Senior high (10–12, 7–12) | 33.9 | 28.1 | 31.1 | 33.9 | 28.1 |
| No. | 3,722 | 5,501 | 2,957 | 1,637 | 1,520 |

[a] Data on ethnicity were not collected until 1978.

Three related functions are used in survival analysis to describe the distribution of time until the event of interest (i.e., attrition) occurs: (1) The survival function, *F(t)*, is the probability that the event under study has not occurred at time *t*. In our analysis, *F(t)* is the probability that the individual has not left teaching at time *t*, where *t* is the number of years that have elapsed since the individual entered teaching. This can also be viewed as the proportion of a cohort that has taught for $t$ years. Simply stated, the survival function is a plot that indicates how likely it is that the teacher will survive in teaching beyond the first year, the second year, and so on. At the beginning of the first year of teaching (the entry year), 100 percent of the teachers are "alive" (hence the term "survival" analysis). As time passes, teachers gradually leave the profession or "die" and the likelihood of survival gradually drops to zero, although we may never observe this because of right-censoring. Our estimate of the cumulative attrition rate, or the proportion of an entering cohort that will leave teaching within $t$ years, is $1 - F(t)$. (2) The probability density function is given by $f(t) = -dF(t)/dt$. It gives the instantaneous rate of attrition at time $t$ for all individuals. (3) The hazard function, $h(t) = f(t)/F(t)$, is the instantaneous rate of attrition at time $t$ for those who are still teaching at time $t$. We will refer to $h(t)$ as the attrition rate. This hazard function describes the risk of leaving teaching at a given time. For example, is the second year of teaching particularly risky? Is the third year less risky than the second year? In other words, given that a teacher has survived through two years of teaching, what is the probability that he or she will leave in the third year?

We use two survival analysis techniques to study when attrition occurs. The first, called the Kaplan-Meier estimator, is a descriptive technique that allows us to examine the distribution of attrition times. The Kaplan-Meier estimator, often referred to as a life-table estimator, is a nonparametric estimator that makes no assumptions about the distribution of the survival function but corrects for sample losses stemming from censored observations before time $t$. If we let $n(j)$ be the number of new teachers who have not left teaching after $j$ years, and $d(j)$ be the number who leave in this period, then the attrition rate at time $j$, $h(j)$ is given by $h(j) = d(j)/n(j)$. The survival function can be estimated as:

$$F(t) = \Pi(1 - h(j)),$$

where the product runs from the initial period to $t - 1$ (Kalbfleisch and Prentice, 1980; Cox and Oakes, 1984). We also use the Kaplan-Meier estimator to see how the timing of attrition varies across teachers who have different demographic characteristics. The Kaplan-Meier estimators for different subgroups allow us to see how variations in one characteristic affect the timing of attrition. This reveals the gross effect of that characteristic and everything else that varies with it. For example, because most elementary teachers tend to be women, Kaplan-Meier estimators for teachers of different grade levels also include any effect of being female on the attrition decision. To estimate the net effect of a characteristic, controlling for other characteristics, we need to use multivariate techniques. These are discussed in Sec. V. Here we present the Kaplan-Meier estimators for different subgroups of interest.

## RESULTS

### Attrition Differences by Cohort

Figures 4.3–4.4 present the annual and permanent attrition rates for selected cohort years (1965–66, 1970–71, 1975–76, 1980–81, and 1982–83). As can be seen, the survival rates improved dramatically over time from 1965–66 to 1975–76: The proportion of the cohort leaving after two years fell from 38 percent to 22 percent. The 1980–81 cohort had higher attrition rates than the 1975–76 cohort but the 1982–83 cohort experienced lower attrition than the 1980 cohort. A closer examination of the various cohorts and early attrition rates suggests that there may have been RIFs in the years 1977–80, although the evidence appears somewhat mixed. This would bias our estimates of survival rates because we are not disentangling involuntary separations from voluntary separations and the two groups are likely to behave somewhat differently. Permanent attrition rates display the same trend (Fig. 4.4) as seen in Fig. 4.3, with long-term attrition being lower for the later cohorts. This point is more easily made by looking at Fig. 4.5, which presents cumulative three-year attrition rates for each cohort. Attrition declined markedly for the 1968 through 1975 cohorts. The three-year experience of the 1976–82 cohorts suggests that attrition increased markedly perhaps as a result of a RIF probably in the 1977–80 time period. The later cohorts have considerably lower attrition rates. This holds true for both annual and permanent attrition.

We find that the experience of more recent cohorts (for which, of course, we have a much shorter history) suggests that the downward trend in attrition is continuing. We can advance several hypotheses for this finding. First, teacher salaries have been increasing over this time period. (This is only part of the explanation, however: After all, real teacher salaries were high during the late 1960s and early 1970s and attrition was at its highest during that time period.) Another ex-

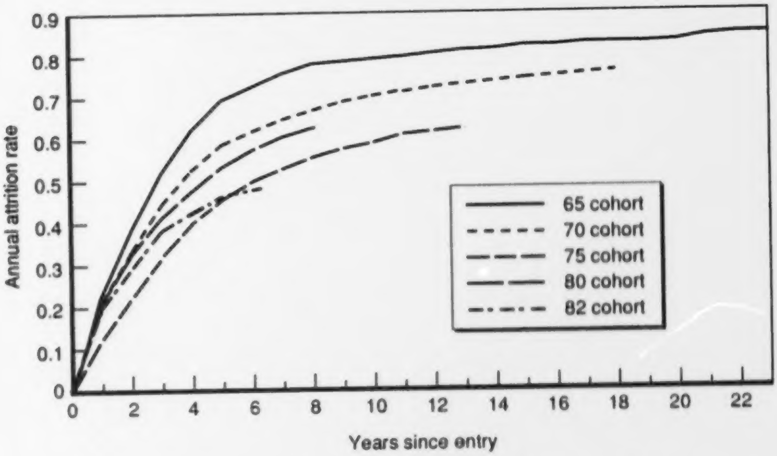


Fig. 4.3—Annual attrition from teaching of selected cohorts, by years of experience

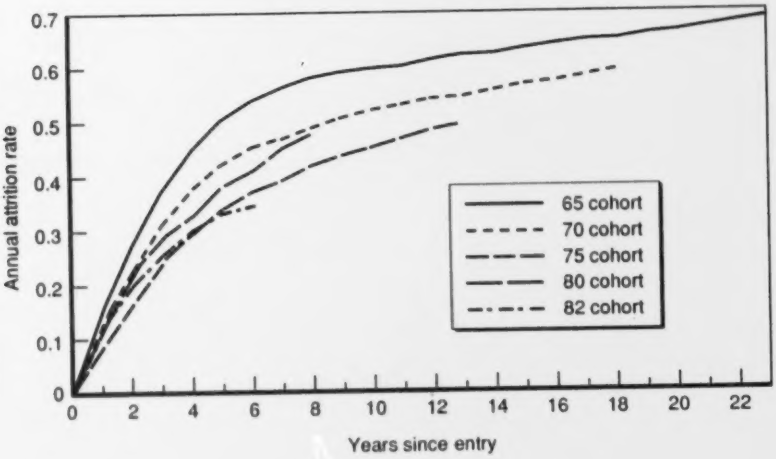
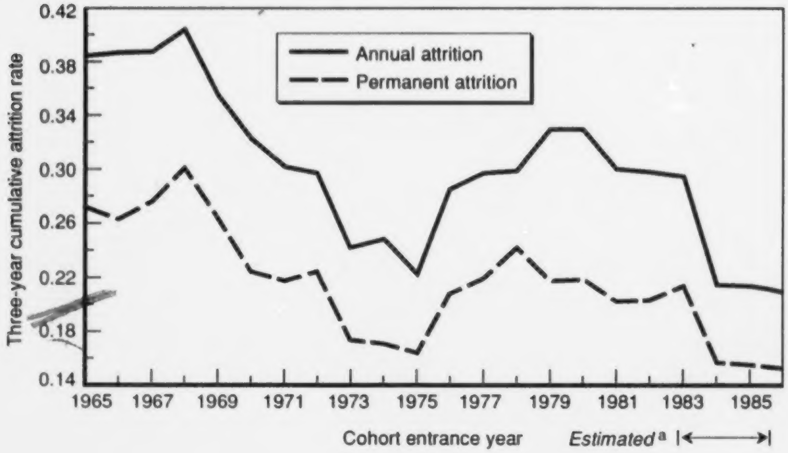


Fig. 4.4—Permanent attrition from teaching of selected cohorts, by years since entry



[a] Permanent attrition rates are estimated from 1983–1987 using historical return rates.

**Fig. 4.5—Three-year attrition rates, by year**

planation revolves around the aging of the new teacher cohorts. As we see in Fig. 4.6, the proportion of entering teachers age 30 and older has been rising, particularly during the 1980s, whereas the proportion of younger teachers has been declining substantially. We had earlier suggested reasons why older teachers are more likely than younger ones to stay in teaching—greater family and geographical stability, older children, and better informed decisions. Third, we had hypothesized that during periods of low demand, attrition is likely to be low because of the fear that it may be difficult to find alternative teaching jobs or perhaps to return later to teaching. As is clear from Fig 4.1, the cohort size of new hires declined in the 1970s and remained rather small during the early 1980s (around 1,500) compared to over 5,000 during the late 1960s and early 1970s.

At first glance, the marked difference in the attrition experience of cohorts over time argues for analyzing the cohorts separately. When we did so, however, we found that the *patterns* of attrition for various subgroups were remarkably similar across cohorts. In analyzing differences among groups categorized by demographic characteristics or by subject specialty, we decided to combine the cohorts and to use the combined cohort data to analyze the differences.

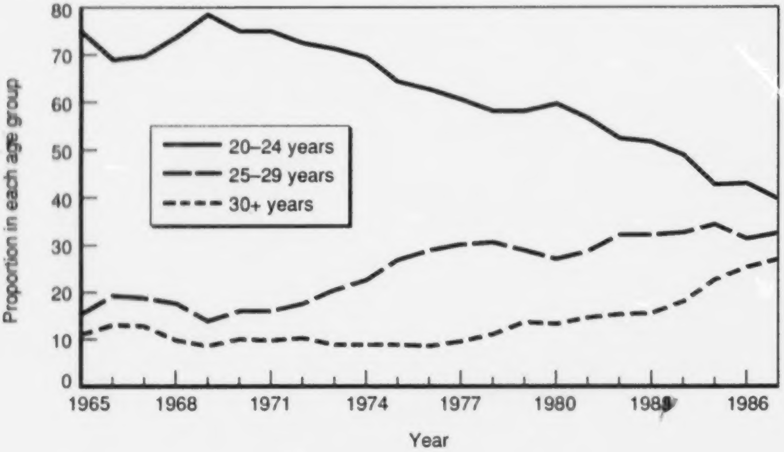


Fig. 4.6—Age distribution of new teachers, by year

The results presented here are for the combined cohorts of new teachers from 1965–82. We investigate differences in survival probability for various subgroups of these cohorts categorized by gender, race, age, year, and subject area taught. We define two dependent variables, based on the distinction we made earlier between temporary and permanent attrition. The first corresponds to examining the first *continuous* spell of teaching and the second examines the proportion of the cohort that is *still* teaching in a given year, regardless of interruptions in the spell of teaching.

## Timing of Attrition

The Kaplan-Meier estimators of the attrition function for the combined cohorts of new teachers are shown in Fig. 4.7. The horizontal axis shows the length of time in years since entering teaching. The vertical axis measures the cumulative proportion of teachers who will leave teaching by that time. The two curves correspond to our two definitions of attrition. The first, which we refer to as annual attri-

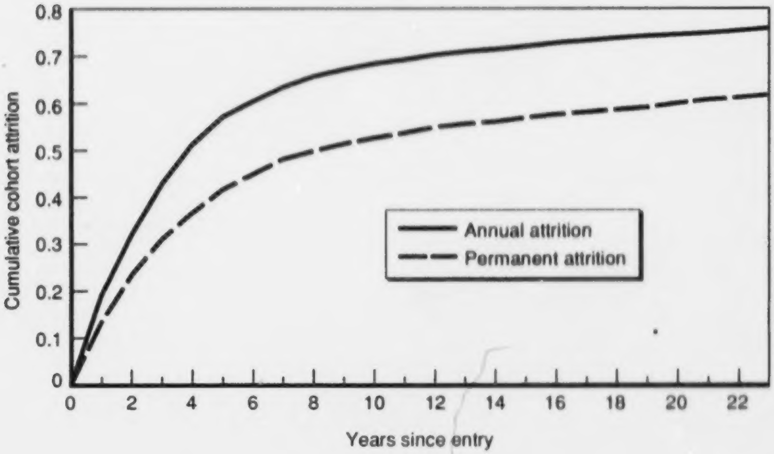


Fig. 4.7—Attrition from teaching of combined cohorts, 1965–82

tion, examines whether teachers are teaching continuously. If they leave in any given year, they are counted in the numerator of the attrition rate. The second, permanent attrition, counts individuals as leavers only if they leave and do not subsequently return to teaching within the data period.

Looking first at annual attrition, we find that the largest proportion of teachers will leave one year after entering teaching, a little under a fifth of the cohort. Another 13 percent will leave by the end of the second year. By the end of the fourth year, a little over half of the cohort will have left teaching. Only about a third of the cohort will teach continuously for 10 years. The proportion of the cohort leaving each year declines fairly sharply over time: In the sixth and seventh years, only 3 percent of the cohort leaves teaching as compared to 10 percent in the third year, 8 percent in the fourth year, and 6 percent in the fifth year. After 10 years, the curve starts to flatten out and the proportion leaving each year is close to 1 percent. Twenty years after entering teaching, only about a quarter of the cohort survives. The same pattern emerges when we examine permanent attrition. For example, 19 percent of teachers did not return in the following year (annual attrition), but only 14 percent left permanently. The difference represents teachers who left for at least a year, but returned at a later date. Allowing for breaks and subsequent returns to teaching, we find that half of the cohort will leave within 10 years of entering teaching. Ten years after entering teaching, the curve flattens out and attrition is from one-half to 1 percent a year. About 40 percent of the original cohort survives by the twentieth year, although, of course, they have not been teaching continuously, without breaks in service.

## Attrition Differences by Demographic Characteristics

Attrition differs markedly for different demographic groups as shown in Figs. 4.8–4.10. These graphs show the cumulative attrition rate since entry into teaching for each group. Figure 4.8 shows the annual and permanent attrition rate functions for men and women teachers. Men clearly have much lower rates of attrition than women, generally about 25 percent lower. Two years after entry, 28 percent of the men drop out as compared to almost 35 percent of the women. By the fourth year, well over half (55 percent) of the women have left teaching at least once; the corresponding number for men is only 43 percent. However, the differences are much smaller when one

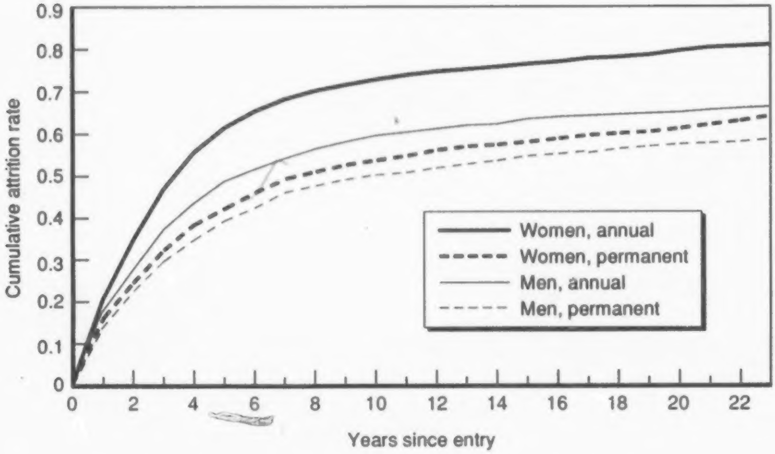


Fig. 4.8—Attrition from teaching of combined cohorts, by gender, 1965–82

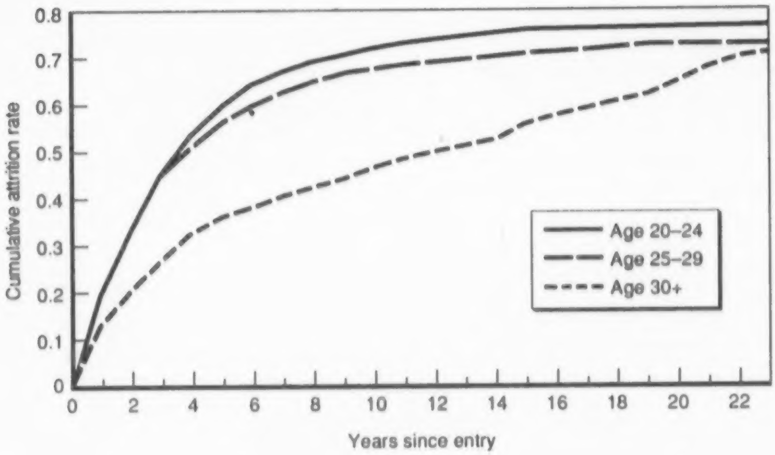


Fig. 4.9—Annual attrition from teaching of combined cohorts, by age, 1965–82

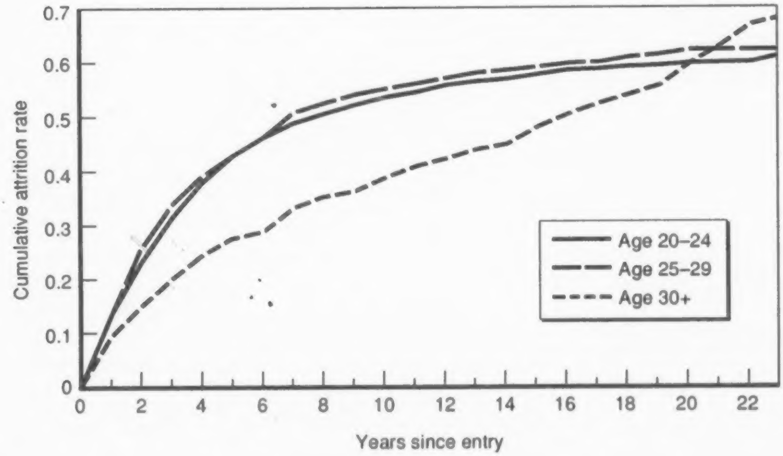


Fig. 4.10—Permanent attrition from teaching of combined cohorts, by age, 1965–82

examines permanent attrition. If returnees are not counted as having separated, then the difference in the attrition rate is only from 7–10 percent. For example, after two years, about 24 percent of the women have separated from teaching as compared to 22 percent of the men. Four years later, the ratio is still about the same (with 38 percent of the women having left teaching compared to 35 percent of the men). This reinforces what we saw earlier, looking at trends in attrition—that women tend to drop out more frequently than men but tend to return more frequently as well.

Older teachers (30 years and older) tend to stay in teaching much longer than younger teachers (Fig. 4.9). Young teachers, those younger than 25, appear to be at greatest risk of leaving. At the end of two years, about a third of those who were younger than 30 at entry have separated from teaching as compared to a little over a fifth of those over 30. However, by the end of the fifth year, we find that 60 percent of the youngest age group (20–24 years), 56 percent of the middle age group (25–29 years), and 37 percent of those 30 and older have left teaching. By the fifteenth year, the difference is not quite so large: The attrition rate for the youngest group is only about 34 percent higher than that of the oldest group and this difference becomes smaller as the latter comes closer to retirement. Figure 4.10 examines the return-adjusted rate of attrition. The pattern is very similar, although the differences among the age groups are not quite so marked. By the twentieth year, we find that the attrition rates for all three groups are from 60–62 percent. Beyond that, the attrition rate for the oldest group actually becomes higher than for the younger groups as teachers in the former age group retire.

### Attrition Differences by Subject Taught

One of the most important questions regarding teacher attrition is whether there is a differential pattern of attrition by subject area and have these differences (if there are any) remained stable over time. For example, do mathematics and science teachers have higher attrition rates than those teaching other specialties? Do they tend to return less frequently?

Teachers were categorized by their primary assignment areas into different subject specialties. Figures 4.11–4.12 present attrition differences by subject area for the two definitions of attrition. Because the multiplicity of subjects makes the graphs difficult to read, we

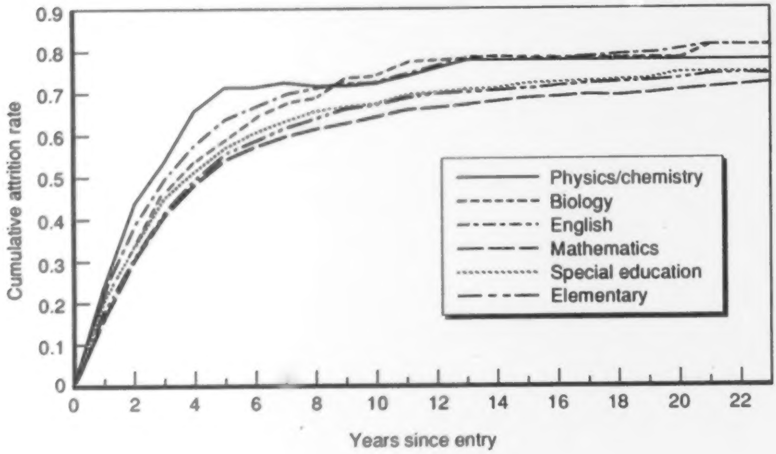


Fig. 4.11—Annual attrition from teaching, by subject taught

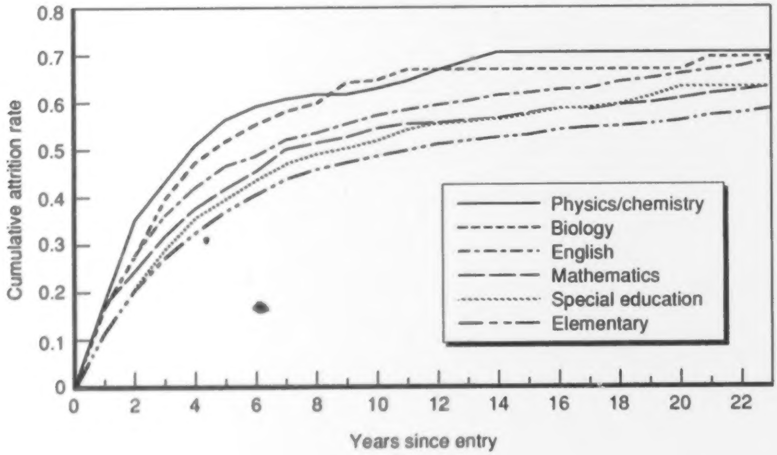
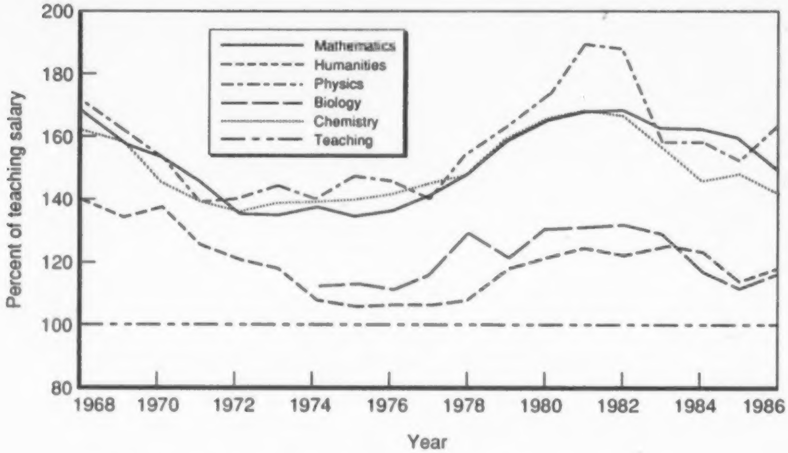


Fig. 4.12—Permanent attrition from teaching, by subject taught

have shown attrition rates for the first 10 years of teaching only. The curves mostly appear to level off after this time period, so we do not lose a great deal of information by doing so. Our findings reinforce what others (for example, Murnane, Singer, and Willett, 1988) have found. The highest rates of attrition are found among physics/ chemistry, English, and biology teachers. By the end of the fifth year, only 30 percent of the original cohort of physics/chemistry teachers have been teaching without a break in service, 70 percent of them having separated at least once. Approximately 60 percent of the English and biology teachers have left teaching (at least temporarily). Contrary to popular opinion, mathematics teachers have among the lowest rates of attrition, along with elementary teachers. Differences in attrition are a little more marked and follow a somewhat different pattern when one looks at permanent or return-adjusted attrition (Fig. 4.12). Here, we find that science teachers (physics/chemistry, biology) have the highest rates of attrition and elementary teachers have the lowest rate of attrition. For example, five years after entering teaching, we find that about 38 percent of the elementary teachers have left and never returned (given the limits of our data); the corresponding number for physics/chemistry teachers is 57 percent and for biology teachers 52 percent. Mathematics and English teachers fall in between (42–47 percent). This implies that science teachers not only leave more frequently but also are less likely to return than other types of teachers. Although mathematics teachers have relatively low rates of attrition, they do not tend to return to teaching after a break in service; hence, their permanent rates of attrition are much higher than one would expect from looking at annual rates of attrition. Special education teachers appear to have a higher likelihood of returning to teaching. These results may be partly explained by the differential outside opportunities available to teachers in the different fields. As Murnane, Singer, and Willett (1988) point out, starting salaries in business and industry for graduates majoring in science (physics, chemistry, and biology) have been consistently higher than starting salaries for other graduates (see Fig. 4.13), and this may help explain the higher annual and permanent attrition rates for science teachers. An additional explanation revolves around working conditions for teachers—perhaps science teachers are more likely than teachers of other subjects to be hampered and frustrated by the lack of equipment, materials, and space and so are more prone to leave.



SOURCES: College Placement Council; National Education Association.

**Fig. 4.13—Starting salaries, by field**

The results for mathematics teachers are puzzling. After all, starting salaries for mathematics graduates have been almost as high as those for science graduates. A plausible explanation offered by Murnane, Singer, and Willett (1988) is that high-paying jobs in business and industry may be available only to those mathematics teachers who teach advanced mathematics courses and not to the majority of teachers teaching algebra, geometry, and remedial math.

A useful way of summarizing the differences among the various groups seen in the figure is to examine the median lifetime of a typical teacher within that group. This statistic, which captures how rapidly the survivor function drops, represents the length of time that must pass before 50 percent of the teaching force leave teaching, and its value can be easily obtained by simple graphical interpolation on the survival probability plot. Table 4.2 shows the median survival times for typical teachers in each of the subgroups for the unadjusted and return-adjusted definitions of attrition.

## Table 4.2

### MEDIAN SURVIVAL TIME IN YEARS FOR SELECTED GROUPS

| | Median Survival Time (Years) | |
|---|---|---|
| Selected Group of Teachers | Annual Attrition | Permanent Attrition |
| Overall | 3.9 | 8.2 |
| Male | 5.5 | 9.7 |
| Female | 3.5 | 7.6 |
| Age 20–24 | 3.6 | 7.4 |
| Age 25–29 | 3.9 | 6.9 |
| Age 30+ | 11.9 | 15.9 |
| Nondepartmental (elementary) | 4.2 | 10.9 |
| Special education | 3.8 | 8.4 |
| English | 3.0 | 6.3 |
| Mathematics | 4.1 | 6.9 |
| Physics/chemistry | 2.6 | 3.8 |
| Biology | 3.5 | 4.5 |
| Other science | 3.5 | 6.5 |
| Other departmental | 3.9 | 6.9 |

The graphs displayed here present the total effect of a characteristic and everything correlated with that characteristic, rather than the incremental or net effect of that variable alone, holding all the other variables constant. The next section presents a multivariate model that estimates the net effect of each characteristic on attrition.

# V. MULTIVARIATE ANALYSIS OF TEACHER ATTRITION

Using multivariate techniques is particularly important in studying teacher attrition. One key question, for example, regarding the attrition patterns we see among subject specialties is whether these are due to the varying proportions of men and women teachers within a specialty or whether there is something inherent in the specialty itself that is responsible for the difference in attrition.

To estimate the net effect of each variable, we fit a Cox proportional hazards model (Cox, 1972). Similar to multiple regression analysis, this technique estimates the separate effects of several variables on the hazard rate. This model assumes that the attrition rate function for an individual with characteristics given by $x$ is:

$$h(t;x) = g(x)h_0(t),$$

where $h_0(t)$ is an underlying attrition rate function and $g(x)$ is a function of the characteristics. In the Cox proportional hazards model, no assumptions are made about the underlying model for the attrition rate, $h_0(t)$. In this context, this assumption is not limiting because in the multivariate analysis, we are more interested in how differences in characteristics shift the hazard function, and less interested in describing the shape of the function. However, an important assumption of the Cox model is that the effect of an increase in a given characteristic, say $x$, is to multiply the attrition rate by a constant factor $g(x)$, so that the attrition rates for groups of individuals with different levels of $x$ are proportional (hence the term "proportional hazards model").

Since the attrition rate must be greater than zero, a commom form for $g(x)$ is $g(x) = exp(bx)$, where $b$ denotes the regression coefficients to be estimated. Here, the multiplicative effect on the attrition rate of an increase in $x$ is given by $exp(b)$. A concrete example may help to illustrate this point. Assume we have a reference individual whom we will characterize by $x = 0$; the attrition rate function for the reference individual is then the (unspecified) $h_0(t)$. A second individual is similar to the reference individual in all respects, except that the second individual differs in one characteristic; for example, the individidual is male rather than female, $(x_1 = 1)$. For the second individual, we have

$$h(t;x_1 = 1, x_2 \ldots x_n = 0) = exp(b_1)h_0(t),$$

or,

$$h(t;x_1 = 1, x_2 \ldots x_n = 0) / h_0(t) = exp(b_1).$$

Thus, for example, if we estimate $exp(b_1) = 0.95$, this indicates that at any point in time the probability of attrition for men is 5 percent lower than for women.

We estimate two different cohort attrition models. The first set analyzes annual and permanent attrition for all cohorts from 1965–82 and follows each cohort through 1988. This means that each cohort is followed for different lengths of time—the 1965–66 cohort for 23 years, the 1982–83 cohort for six years. We use these results to determine the effects of variables such as gender, age at entry, and subject taught that in our model do not change over time, and to determine basic trends in cohort attrition while controlling for these factors. By combining the cohorts, we obtain large sample sizes even in subject specialties with small numbers of teachers (such as physics/chemistry and mathematics).

The second model focuses on annual cohort attrition only[1] through the first four years of teaching for all cohorts from 1965–66 to 1982–83. We follow each cohort only through the first four years. This is the period of highest attrition when we expect the greatest sensitivity to teacher salary and teacher working conditions. It also allows us to associate specific salary, working condition, and labor-force variables with cohorts during their initial working years.[2]

All models are estimated for men and women separately. Joint estimates for men and women teachers show markedly different attrition behavior and the need for separate analysis. The basic explanatory variables in the first set of models are the same: age and subject taught. In addition, the first set analyzing attrition over the entire time period also includes a set of cohort dummies to see whether attrition patterns have changed over the time period.

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[1] We do not estimate this model for permanent attrition. The bias that exists in permanent attrition as a result of censoring of more recent observations is also time-dependent and we felt that the other time-varying coefficients would be biased. In addition, the data show evidence of possible RIFs in the late 1970s, and RIFs are likely to affect the possibility of return, introducing a further time-varying bias.

[2] A better method of accounting for time-varying covariates would be to use hazard models with time-varying covariates. This method actually associates changes in the values of time-varying variables during each cohort's life, rather than simply associating a time-varying value with each cohort. We approximate these results by using only a short four-year life for each cohort during which we usually ignore changes in the value of the independent variables. However, in the case of teacher pay, we introduce an explicit variable that measures the relative change in pay from the first to the fourth year. Future research will include estimation by time-varying covariates.

The second set, which we will refer to as the four-year attrition model, includes starting teacher salary, the ratio of the average cohort beginning salary to its fourth year salary (a proxy for the changing wage experience of the cohort), and student-teacher ratio, a proxy for working conditions. We also include the labor-force participation rate for men and women. We believe this may help explain some patterns of attrition specific to women; as the labor-force participation rate of women has grown over time, staying in the labor force has become more acceptable and has helped reduce attrition. A final variable is the median income of college-educated men and women, age 25–29 years, employed full-time in the United States. This is our best measure of the opportunity cost of teaching; in other words, it provides a measure of wages in other occupations for labor-force participants of similar age and education. The base teacher salary is, of course, specific to the teacher; the other variables are all year-specific from 1965–82.

For teacher salary, we use both entry pay for a cohort and the relative change in pay over the first four years of a cohort's life. Entry-level pay influences attrition directly by establishing expectations of future pay levels and also by partly determining who decides to teach. In the latter case, higher pay levels may attract individuals with different tastes for teaching than otherwise would be the case with lower pay levels.

The actual growth in salary partly influences year-to-year decisions to leave over the cohort life. Salary growth establishes a firm expectation for future career salary levels that is partly independent of initial salary. In the time period covered by this analysis, the salary growth variable is important because inflation rates were very high during part of the period, and salary growth was strongly influenced by the declining demand for teachers in the 1970s. During this period, salary growth lagged far behind inflation. This is partly due to the high rate of inflation but was also probably a result of bargaining between teacher unions and school corporations. During this period, falling enrollments made involuntary separations a strong possibility, and a cap on salary growth may have been accepted in return for an agreement to save teacher jobs.

In addition, we have incorporated dummy variables in the model to control for the possible RIFs that may have taken place between 1977–80.[3]

## ATTRITION OVER THE CAREER: RESULTS

The means of the variables used in the models are given in Table 5.1. Tables 5.2–5.3 present the estimation results for the two definitions of attrition: annual attrition and return-adjusted or permanent attrition for the longer-run attrition model. What we have chosen to present in these tables, for reasons of clarity and brevity, are the multiplicative factors defined as *exp(b),* where *b* is the estimated coefficient. The coefficient estimates along with their *t*-values are given in the appendix. These multiplicative factors summarize in a simple and readable fashion the effects of the variables on attrition and are easily interpreted. For example, for the continuous variables, such as salary, median income, labor-force participation rates, and student-teacher ratios, the multiplicative factor gives the proportional shift in the attrition rate associated with a unit increase in the variable (an increase of $1,000 in income, an increase of 1 in the student-teacher ratio, and an increase of 1 percentage point in the labor-force participation rate). For the other characteristics, the multiplicative factor shows the shift in the attrition rate for an individual with the particular characteristic (e.g., age 30 years and older) relative to that for an otherwise similar individual with the reference or omitted value for that characteristic (e.g., age 25–29 years).

The tables present the results of two separate specifications of the model, one with age and subject specialty, the other with age, subject specialty, and cohort year dummies for the combined sample, and for men and women separately.

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[3] The evidence for a RIF comes from several sources. First, there was a rapid decline in the total number of teachers in the late 1970s combined with very low hiring levels. This was also the period of falling enrollments. The age-specific attrition data show that very young and very old teachers had uncharacteristic changes during the period 1976–79. RIFs would be expected to fall on younger teachers, and their attrition rates show declines that are not present for mid-career teachers. Also, higher attrition for older teachers indicates an effort to increase early retirement—a policy likely to take place during RIFs. The other somewhat weaker evidence for a possible RIF is the return rates for leaving teachers. One would expect such teachers, because they were separated involuntarily, to return earlier and more frequently than those who separated voluntarily. Evidence from return data shows this to be the case, although strong hiring in the early 1980s to meet mandated lower student-teacher ratios may also account for earlier returns.

## Table 5.1

### MEANS OF VARIABLES USED IN THE COX MODEL

| | Mean | | |
|---|---|---|---|
| Variable | Combined Sample | Male Sample | Female Sample |
| Age 20–24 | 0.69 | 0.66 | 0.71 |
| Age 25–29 | 0.21 | 0.28 | 0.17 |
| Age 30+ | 0.10 | 0.06 | 0.12 |
| Male | 0.31 | — | — |
| Female | 0.69 | — | — |
| Nondepartmental (elementary) | 0.42 | 0.24 | 0.50 |
| Special education | 0.07 | 0.03 | 0.10 |
| English | 0.12 | 0.10 | 0.13 |
| Mathematics | 0.07 | 0.11 | 0.04 |
| Physics/chemistry | 0.01 | 0.01 | 0.002 |
| Biology | 0.01 | 0.02 | 0.004 |
| Other science | 0.01 | 0.03 | 0.01 |
| Other departmental subjects | 0.29 | 0.46 | 0.21 |
| Basic salary (1987 $ 000s) | — | 19.71 | 19.01 |
| Salary growth ratio | — | 0.91 | 0.91 |
| Student/teacher ratio | — | 24.01 | 24.01 |
| Labor-force participation rate | — | 0.82 | 0.55 |
| Median income (1980 $ 000s) | — | 18.64 | 13.81 |
| Year 1965–67 | 0.20 | 0.21 | 0.20 |
| Year 1968–70 | 0.26 | 0.27 | 0.25 |
| Year 1971–73 | 0.21 | 0.19 | 0.22 |
| Year 1974–76 | 0.15 | 0.15 | 0.15 |
| Year 1977–79 | 0.12 | 0.12 | 0.12 |
| Year 1980–82 | 0.06 | 0.06 | 0.06 |
| Year 1977 | — | 0.04 | 0.04 |
| Year 1978 | — | 0.04 | 0.04 |
| Year 1979 | — | 0.04 | 0.04 |
| Year 1980 | — | 0.03 | 0.03 |
| No. | 15,323 | 4,781 | 10,642 |

## Results for the Combined Sample

The effects of demographic characteristics on attrition are large and important. As with the descriptive analysis, the difference between those who enter teaching at age 30 or older and the omitted

## Table 5.2

### MULTIPLICATIVE FACTOR ESTIMATES FOR COX REGRESSION ON TIME TO ATTRITION FROM TEACHING, 1965–82 COHORTS: ANNUAL ATTRITION

| | Dependent Variable: Annual Attrition | | | | | |
|---|---|---|---|---|---|---|
| | Combined Sample | | Males | | Females | |
| Variable | I | II | I | II | I | II |
| Age at entry | | | | | | |
| Age 20–24 | 1.055* | 1.014 | 0.947 | 0.939 | 1.110** | 1.038 |
| Age 30+ | 0.606** | 0.573** | 1.156 | 1.151 | 0.535** | 0.487** |
| Gender | | | | | | |
| Male | 0.649** | 0.632** | — | — | — | — |
| Subject specialty | | | | | | |
| Special education | 0.955 | 1.084* | 1.422** | 1.487** | 0.900** | 1.064 |
| English | 1.248** | 1.247** | 1.523** | 1.524** | 1.192** | 1.192** |
| Mathematics | 1.064 | 1.099* | 1.137 | 1.136 | 1.062 | 1.155** |
| Physics/chemistry | 1.558** | 1.586** | 1.736** | 1.724** | 1.263 | 1.497 |
| Biology | 1.403** | 1.405** | 1.549** | 1.439** | 1.327 | 1.382 |
| Other science | 1.241* | 1.113 | 1.301* | 1.242 | 1.351* | 1.207 |
| Other departmental | 1.141** | 1.168** | 1.210** | 1.219** | 1.125** | 1.153** |
| Cohort year | | | | | | |
| 1968–70 | — | 0.872** | — | 0.962 | — | 0.836** |
| 1971–73 | — | 0.703** | — | 0.852** | — | 0.648** |
| 1974–76 | — | 0.612** | — | 0.821** | — | 0.537** |
| 1977–79 | — | 0.673** | — | 0.961 | — | 0.577** |
| 1980–82 | — | 0.617** | — | 0.708** | — | 0.569** |

NOTES: The reference characteristics are age 25–29 years, female, subject specialty, elementary, 1965–67 cohort years. These factors show the shift in the attrition rate for an individual with the particular characteristic relative to that for an otherwise similar individual with the reference or omitted value for that characteristic.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

group, those age 25–29 years, is quite striking. In the combined sample, the hazard of attrition—other things equal—is 39–43 percent lower for the older group when we look at annual attrition and about 25–27 percent lower when we consider permanent attrition. We had earlier suggested several reasons why older teachers might be more likely to have lower attrition than younger teachers: Older teachers are likely to be a self-selected group with greater stability with respect to family and spouse's job. Given that they are entering a profession late, they are likely to have made more reasoned and informed decisions and perhaps to have higher costs of retraining for another occupation.

## Table 5.3

### MULTIPLICATIVE FACTOR ESTIMATES FOR COX REGRESSION ON TIME TO ATTRITION FROM TEACHING, 1965–82 COHORTS: PERMANENT ATTRITION

| | Dependent Variable: Permanent Attrition | | | | | |
|---|---|---|---|---|---|---|
| | Combined Sample | | Males | | Females | |
| Variable | I | II | I | II | I | II |
| Age at entry | | | | | | |
| Age 20–24 | 0.952 | 0.934** | 0.872** | 0.871** | 0.993 | 0.955 |
| Age 30+ | 0.751** | 0.729** | 1.214* | 1.201* | 0.681** | 0.648** |
| Gender | | | | | | |
| Male | 0.821** | 0.813** | — | — | — | — |
| Subject specialty | | | | | | |
| Special education | 1.072 | 1.141** | 1.329** | 1.353* | 1.034 | 1.131** |
| English | 1.294** | 1.293** | 1.484** | 1.481** | 1.248** | 1.248** |
| Mathematics | 1.206** | 1.224** | 1.206* | 1.205** | 1.242** | 1.294** |
| Physics/chemistry | 1.682** | 1.681** | 1.711** | 1.680** | 1.623 | 1.824* |
| Biology | 1.553** | 1.550** | 1.651** | 1.658** | 1.455* | 1.485* |
| Other science | 1.228* | 1.148 | 1.206 | 1.182** | 1.416* | 1.317 |
| Other departmental | 1.230** | 1.243** | 1.239** | 1.239 | 1.228** | 1.244** |
| Cohort year | | | | | | |
| 1968–70 | — | 0.908** | — | 1.002 | — | 1.873** |
| 1971–73 | — | 0.776** | — | 0.921 | — | 0.726** |
| 1974–76 | — | 0.691** | — | 0.848* | — | 0.631** |
| 1977–79 | — | 0.763** | — | 1.006 | — | 0.675** |
| 1980–82 | — | 0.938 | — | 1.021 | — | 0.893[a] |

NOTES: The reference characteristics are age 25–29 years, female, subject specialty, elementary, 1965–67. These factors show the shift in the attrition rate for an individual with the particular characteristic relative to that for an otherwise similar individual with the reference or omitted value for that characteristic.

[a] For the 1980–82 cohorts, the estimates may be biased because we do not have as long a history for these cohorts as for earlier ones.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

The results for the youngest age group are much smaller than for the over-30 group and show different tendencies for annual and permanent attrition. For annual attrition, the results show a slightly higher (1–5 percent) attrition rate for those age 22–24 years compared to those who are 25–29 years. However, for permanent attrition, the 22–24 year age group has a lower attrition rate (5–7 percent) than the reference group.

As we had seen earlier, even controlling for other variables, men have a considerably lower hazard of attrition than do women: 35–37 percent lower with respect to annual attrition. However, given that women are much more likely to return once they leave, we find that the difference between men and women is much smaller (18–19 percent), although still significant, when we consider permanent attrition. We can offer some reasons for these differences. For example, men traditionally have stronger ties to the labor force, particularly if they are the main wage-earners in the household. In addition, women tend to bear a greater responsibility for child-rearing and thus may leave when children are small and return later to teaching. Also, in general, men tend to have a greater set of outside job opportunities than women. As a result, when men do leave, they are more likely to leave for another profession and thus are unlikely to return.

Controlling for other variables, we find marked differences in the likelihood of attrition among different subject specialties. Relative to elementary school teachers, all other departmentalized subject teachers have a higher hazard of attrition (with one exception: special education teachers in the first specification), although some of these differences are rather small as in the case of special education teachers (8 percent) and mathematics teachers (6–10 percent). The highest rates of attrition are to be found among physics/chemistry teachers (56–59 percent higher) who consistently have the highest attrition rates. Biology teachers (40 percent higher) have the next highest rates followed by English teachers (25 percent higher). All other departmentalized subject teachers have a 14–16 percent higher hazard of attrition.

When we examine permanent attrition, the differences are, for the most part, larger and strongly significant and follow a slightly different pattern. This suggests that compared to elementary school teachers, all other departmentalized teachers are less likely to return. We find that the permanent attrition differentials are even larger for physics/chemistry (68 percent higher), for biology (55 percent higher), and for mathematics teachers (21–22 percent higher). This indicates that these types of teachers have relatively lower return rates when leaving.

The grouped yearly cohort dummies provide a measure of attrition trends holding gender, age, and subject distribution constant. Since we know that entering teachers have shifted to an older distribution of teachers, it is important to control for this to find out if the typical teacher entering at different times would have different patterns of attrition. For annual attrition, we find that—other things equal—a typical teacher entering in the 1980–82 cohort would have a 39 percent lower attrition rate than one entering in 1965–67. Attrition of typical teachers entering during 1965–76 fell steadily. It increased for the 1976–79 cohort (perhaps because of the possible RIF) and then continued downward for the 1982–85 cohort. For permanent attrition, we have unbiased results only through the 1965–79 cohorts, and the trend patterns are similar to the annual attrition results.

## Results for the Samples of Men and Women

To test whether the effects of the explanatory variables are different for men and women, we estimated separate models for the two groups. The results (Tables 5.2–5.3) are interesting and suggest that it is important to disaggregate by gender when analyzing teacher attrition.

For example, the effect of age on permanent attrition is completely reversed for the two groups. The risk of leaving grows the later men enter teaching, whereas the risk of leaving declines, in general, the later women enter teaching. The effects are large and statistically significant for permanent attrition. The effect is particularly strong for teachers entering teaching at age 30 or older. A man entering teaching at 30 or older has a permanent attrition rate 20 percent higher than a man age 25–29 years; however, for women who enter when they are older, the attrition rate is 31–35 percent *lower* than for those age 25–29 years. A possible hypothesis for this finding is that older men entering teaching may enter having tried—and perhaps been unsuccessful in—other occupations. These individuals may be self-selected for higher attrition from teaching also. However, women entering later may be more likely to be entering the full-time workforce for the first time after raising families and have less job mobility.

The pattern of permanent attrition by subject specialty is mostly similar for men and women with certain exceptions. Physics/chemistry (68–70 percent higher) and biology teachers (65–66 percent higher) have the highest risk of permanent attrition for both genders when compared to elementary teachers. For men, English teachers (48 percent higher) are the group having the next highest risk, followed by special education (33–35 percent higher) and mathematics (21 percent higher). For women, English (25 percent higher) and mathematics (25 percent higher) teachers appear to be at greater risk than special education teachers.

The trends in attrition as measured by the cohort dummies show somewhat different patterns for men and women. These differences are important in interpreting and explaining overall attrition patterns. For annual attrition, a typical man entering in the 1980–82 cohort would have a 29 percent reduced risk of attrition compared to one entering in 1965–67, whereas a comparable woman would have a 43 percent lower attrition rate. Attrition risks declined for both groups from 1965–76, then increased for the 1977–79 cohorts, then continued declining for the 1980–82 cohort. However, women have shown much larger declines in annual attrition than men.

The permanent trends must be interpreted with caution, since the coefficient for 1980–82 is biased. The trends are similar to the annual attrition trends with the exception that relative male attrition in 1977–79 increased much more drastically than that for women. Since this was a time of lowest real salaries, men may have been more affected by salary declines than women.

Since salary and working conditions are similar for men and women teachers, an explanation for differences in attrition must be sought outside of profession-specific factors. A likely explanation is the changed labor-force participation of women. We test this and other hypotheses in the next subsection.

## ATTRITION OVER THE FIRST FOUR YEARS AFTER ENTRY: RESULTS

### Annual Attrition

The results of the four-year Cox model are presented in Table 5.4. We did not, for the reasons given earlier, estimate this model for permanent attrition.

### Results for the Male and Female Samples

First, the general patterns of attrition by age and specialty appear to be similar in the four-year attrition results and the previous long-run results. The difference between the attrition rate of the older teachers and that of women in the 25–29 year group that we had seen earlier is even more marked in this model. Women teachers entering after age 30 have attrition rates that are 60 percent lower than for those from ages 25–30.

Teacher salaries have varied dramatically over this time period as shown in Fig. 5.1. For example, salaries in constant 1987 dollars increased from 1965 to 1970, when they peaked at around $20,800; they fell continuously after that until 1982, reaching a low of $15,500.

## Table 5.4

### MULTIPLICATIVE FACTOR ESTIMATES FOR COX REGRESSION ON TIME TO ATTRITION FROM TEACHING, 1965–82 COHORTS: ANNUAL ATTRITION DURING FIRST FOUR YEARS OF TEACHING

| Variable | Dependent Variable: Annual Attrition | |
|---|---|---|
| | Men | Women |
| Age at entry | | |
| Age 20–24 | 0.920 | 0.932* |
| Age 30+ | 1.172 | 0.398** |
| Subject specialty | | |
| Special education | 1.382** | 1.109* |
| English | 1.478*** | 1.260*** |
| Mathematics | 1.057 | 1.283*** |
| Physics/chemistry | 1.747*** | 1.587 |
| Biology | 1.287 | 1.581** |
| Other science | 1.300* | 1.416** |
| Other departmental | 1.189*** | 1.187*** |
| Base salary (1987 $ 000s) | 0.947*** | 0.978* |
| Salary growth ratio (4th year salary/base salary) | 1.613 | 0.058*** |
| Student-teacher ratio | 1.113** | 1.016 |
| Labor-force participation rate | 3.222 | 0.058*** |
| Median income of full-time workers (1980 $ 000s) | 1.008 | 1.096 |
| Cohort year | | |
| 1977 | 1.328** | 1.436*** |
| 1978 | 1.473*** | 1.662*** |
| 1979 | 1.402** | 1.657*** |
| 1980 | 1.468** | 1.390*** |

NOTES: The omitted categories are age 25–29 years, teaching nondepartmentalized elementary, earning a mean salary of $19,706 (men), $19,007 (women), or 24.02 students per teacher. Mean labor-force participation rate is 0.82 (men) and 0.54 (women); mean salary growth ratio is 0.91 for both groups. These factors show the shift in the attrition rate for an individual with the particular characteristic relative to that for an otherwise similar individual with the reference or omitted characteristic. For continuous variables, this factor gives the proportional shift in the attrition rate associated with a one unit increase in that variable.

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.

Since then, they have been rising and in 1987 stood at around $17,500. Increases in starting salaries reduce the rate of attrition for

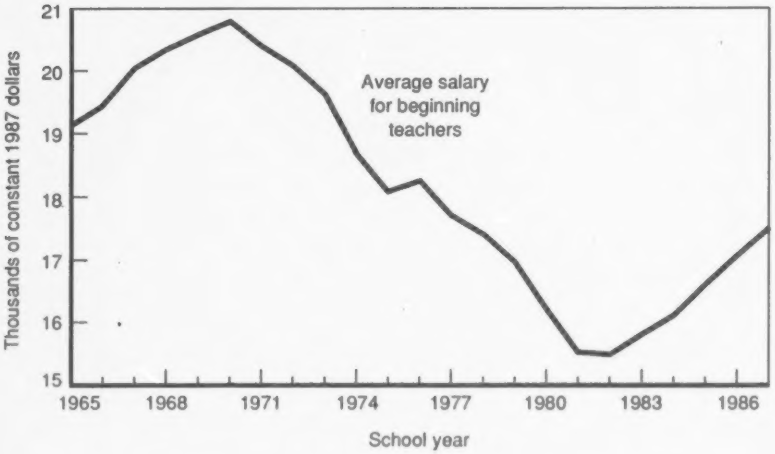

Fig. 5.1—Teacher starting salaries, by year

a cohort and these results are statistically significant at the 1 percent level for men and the 10 percent level for women. The multiplicative factor for salary in the annual attrition model shows that a $1,000 increase in pay reduces attrition by a little over 5 percent for men ((1 – 0.947)*100) and a little over 2 percent for women. Given the average salary for men in our model of $19,706 (in 1987 dollars) (because salary is scaled in the thousands, the mean is really $19.70), a 10 percent increase in salary (i.e., an increase of $1.970) will reduce the attrition rate by a little over 10 percent.[4] For women, using the average salary in the model of $19.01, we estimate that a 10 percent increase in salary will reduce the attrition rate by a little over 4 percent, a much smaller effect.[5] As an example of what this means, consider the attrition rate function shown in Sec. IV. This indicated that 19 percent of new teachers leave after the first year of teaching; with a 10 percent increase in pay, this attrition rate could be reduced to 17 percent, at least among men, and to 18.2 percent among women.

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[4] This is calculated as (1 – *exp*(–0.0544*1.970)), where –0.0544 is the beta coefficient for salary for men. The coefficients are given in the tables in the appendix.

[5] This is calculated as (1 – *exp*(–0.0219*1.901)), where –0.0219 is the beta coefficient for salary for women. See the tables in the appendix.

We find, however, that the salary experience of the cohort appears to play a large and significant role in reducing attrition for women. As a proxy for this, we included the ratio of the fourth year salary to beginning salary (in constant dollars). Among men, the effect is insignificant and actually of the wrong sign. Among women, however, a 10 percent increase in this ratio (the mean of this variable in 0.9078; a 10 percent increase would bring this ratio to approximately 1) would decrease attrition by about 23 percent.[6] This effect suggests that teachers are sensitive both to beginning salaries as well as to the early growth of earnings. The latter probably sets expectations of future salary levels.

We proxied working conditions of teachers by student-teacher ratios. Student-teacher ratios have decreased markedly over this time period as shown in Fig. 5.2. Declines in the 1970s are probably attributable to the effort to maintain teacher employment during a period of sharply declining enrollments. As mentioned earlier, reductions in force became a critical issue during the 1970s as enrollments declined sharply. Three responses to this situation appear to have been: holding salary levels down, decreasing class sizes, and institut-

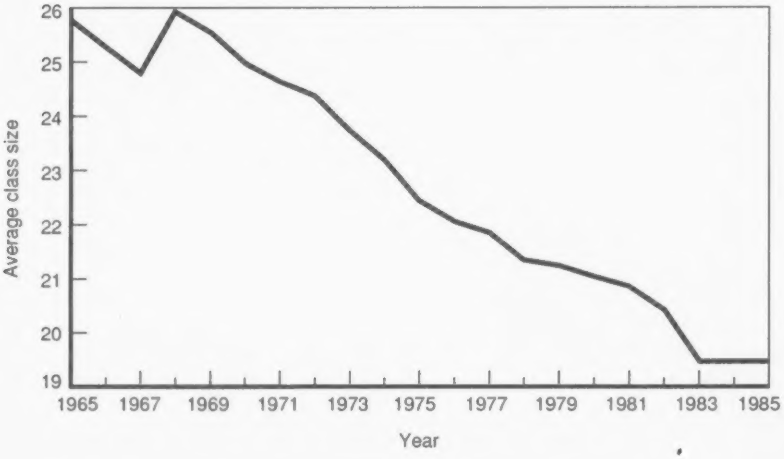

Fig. 5.2—Student-teacher ratio, by year

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[6] This is calculated as (1 – *exp*(–2.8461*.09078)), where –2.8461 is the beta coefficient for salary growth ratio in the appendix tables.

ing involuntary separations. Class sizes also declined in Indiana starting in the early 1980s. This was due to statewide mandated lower class sizes.

We find that this variable has a large and significant effect on men and a smaller but insignificant effect on women. The higher the student-teacher ratio, the greater the attrition, as one would have expected. Among men, a 10 percent increase in student-teacher ratios (from 24.0 to 26.4) would increase attrition by 29 percent. This is calculated as $(1 - exp(0.1067*2.40))$. Among women, the effect is marginal—a 10 percent increase in student-teacher ratios would increase attrition by only about 3 percent $(1 - exp(0.0155*2.40))$. This suggests that women may not be as sensitive as men to working conditions (this might be true, for example, if subjects requiring more equipment and materials were taught mostly by men, such as science, but we have specifically controlled for specialty in the model); however, this result may be due partly to the strong trend component in this variable and women's labor-force participation. The strength of the latter variable for women may be reducing the effect of the student-teacher ratio. More work is needed to link student-teacher ratios with data on individuals rather than statewide averages.

The labor-force participation rate of women has increased sharply over this time period. For example, as Fig. 5.3 shows, among college-educated women age 25–29 years, the participation rate has risen from 43 percent in 1965 to a high of 72 percent by 1985—an increase of 57 percent. We hypothesized that the labor-force participation rate would be important in explaining attrition of women, but not men, who traditionally have had high rates of participation. We find this to be the case. An increase of 10 percent in the participation rate of women—from 0.55 to 0.61—would decrease the attrition rate by 14 percent. This may help explain some of the differences in the rate of decline in attrition rates among women. The effect on men is not statistically significant and actually moves in the wrong direction.

Teacher attrition for women has declined much more than for men from 1966–87. This may simply reflect that women have become much more attached to the labor force—because of both preference and the dependence of families on two incomes. Men's real wages have declined in the 1970s and 1980s, and a second income has become a necessity for most families. This means that women in the labor force were less likely to leave because of their preference for working and their wish not to lose income.

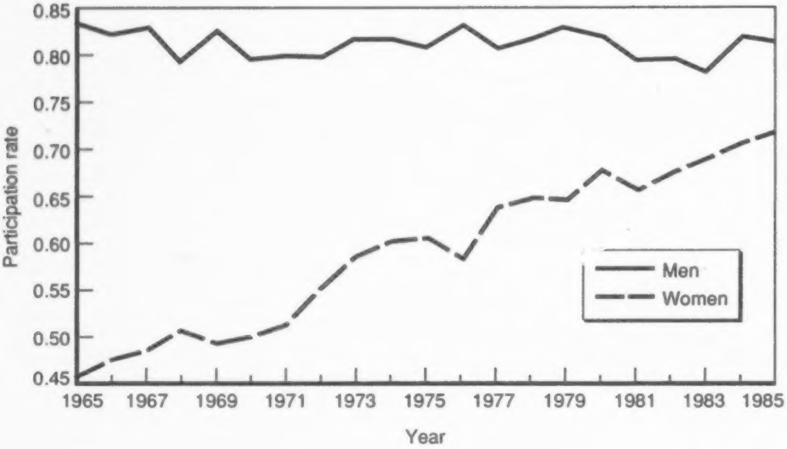

**Fig. 5.3—Labor-force participation rates of full-time workers, by gender and year**

Finally, one can regard the median income of full-time workers as a crude proxy for the opportunity cost of teaching. We used the median income (1980 dollars) of full-time college-educated workers age 25–29 years in the model. This is shown in Fig. 5.4 separately for men and women. It is clear that real incomes, particularly those of men, did decrease over the late 1970s and early 1980s. In our analysis, we find that the variable is not significant for either group, although the direction of the effect is as hypothesized. The higher the income that could be earned in other jobs, the higher will be teacher attrition—a 10 percent increase in median income would increase attrition by 1 percent for men and 14 percent for women.

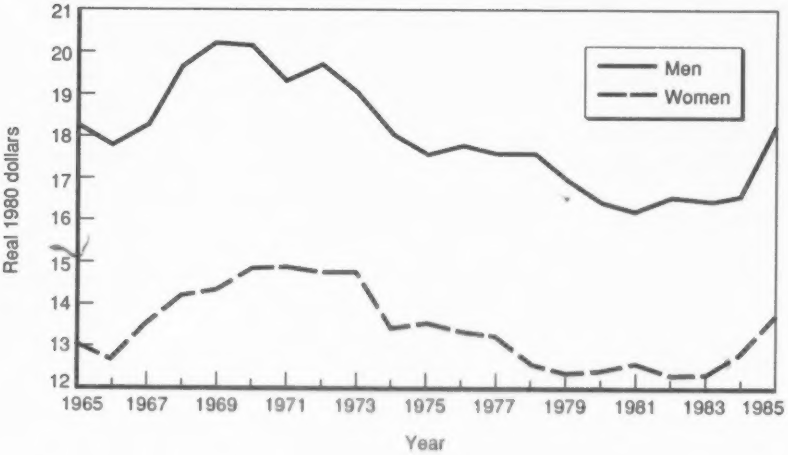

Fig. 5.4—Median income of full-time workers who are college graduates, age 25–29, by year

# VI. CONCLUSIONS

We can draw several tentative conclusions from this study; however, we also outline much additional work that is needed to make the conclusions more robust. This includes other model specifications, incorporating time-varying covariates and improved sets of explanatory variables. Nonetheless, the patterns and trends we see here, using the Kaplan-Meier estimators, are extremely useful because of their implications for teacher supply and the likelihood of shortages in particular specialties.

Perhaps our major contribution in this report is our emphasis on the need to distinguish annual attrition from permanent attrition. Perhaps this would be better categorized as unadjusted attrition, in which every person leaving is counted in the numerator, and return-adjusted attrition, in which individuals who later return to teaching are excluded from the numerator. The fact that many teachers return to teaching needs to be factored into discussions of teacher supply and the much publicized potential for a teacher shortage. Surprisingly, we find that a fairly constant proportion of teachers appear to return—from 25 to 30 percent of those leaving in any given year subsequently return to teaching, and generally within five years of separation.[1] About three-fifths return within two years after a break in service.

Our results show that permanent and annual attrition levels for Indiana teachers whether measured for the entire teaching force or for newly entering cohorts are at their lowest level in 23 years. Permanent attrition rates have dropped from 13 percent in the late 1960s to less than 5 percent in 1987. Attrition among women has dropped more markedly than that of men, and this drop for women is the most important factor in the overall attrition decline. This decline for women can probably be attributed to women teachers following the general trend among women of increased labor-force participation. For women teachers, this means much less frequent dropping out of teaching for marriage or child-rearing, a greater likelihood of returning after dropping out, and much shorter periods of staying out of the teaching force.

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[1] Our viewpoint is, of course, that of the Indiana public school system. Teachers who return to teaching in other states or in parochial schools are still regarded as a loss—we do not have the data that would allow us to track returns to teaching other than in the Indiana public school system.

Another important factor (more so for men than for women) in explaining declines in permanent attrition is beginning teacher salaries. Our estimates (again, subject to the caveat mentioned above) show that a 10 percent increase in salary reduces annual attrition by about 10 percent (4 percent among women). Interestingly enough, women appear to be more sensitive to the erosion in real teacher incomes. If fourth-year salaries had been equal to first-year salaries in real terms, attrition among female teachers would have decreased by 23 percent.

We also find that student-teacher ratios help explain lower attrition, and to the extent that this is a surrogate for teacher working conditions, it supports the importance of working conditions in the retention decision (more so for men than women).

Another factor affecting permanent cohort attrition is the change in the age of entering teachers. We find that older women teachers are a large and growing proportion of entering teachers. Late-entering women teachers have much lower attrition, and this pool of teachers should continue to expand because of the rapid growth in the population age 30–45 years old.

Finally, we find that—other things equal—secondary school teachers have higher permanent attrition than elementary teachers, and that science teachers have much higher attrition than other types of secondary school teachers. Physics and chemistry teachers have permanent attrition rates 80 percent greater than that of elementary teachers. Biology teachers have permanent rates approximately 65 percent greater, and mathematics and English teachers have rates that are about 20–25 percent greater than that of elementary teachers. Somewhat unexpectedly, we find that mathematics teachers do not have higher attrition rates than other types of secondary school teachers. Outside wage opportunities can account for some of these attrition differences. Although the results for mathematics teachers run counter to expectations, one plausible explanation might be that not all mathematics teachers have lucrative outside opportunities—only those who teach advanced mathematics. In addition, for science teachers, we hypothesize that some teaching conditions peculiar to science such as the quality of laboratory facilities, budgets for laboratory supplies, and the extra workload from laboratory classes may account for the large difference we see for these teachers.

Our theory had suggested a U-shaped relationship between age and attrition, with the probability of attrition likely to be much higher during the early stages of the career, very low during mid-career and high as the teacher approached retirement. This pattern holds true not only over a single cohort but over time as well, with the overall curve moving down to reflect the decrease in annual attrition rates over time. Attrition among younger teachers, those age 20–24 years, tends to be rather high—23 percent in 1965 and 13 percent in 1985 compared to overall attrition for these two years of 12.4 and 5.6 percent, respectively. Thus, the attrition rate for young teachers appears to be almost double that for all teachers. The attrition rate falls with age, being the lowest for teachers age 45–54 years. For these teachers, attrition appears to be between 2 and 4 percent. Attrition, not unexpectedly, is higher (10–17 percent, depending on the year at which we are looking) for those age 55 and over, who are approaching retirement.

In comparing permanent with annual attrition among the various age groups, we find that younger teachers tend to return much less frequently than teachers in their thirties; this is, of course, also true of much older teachers who leave teaching because of retirement. Among younger teachers, about 30 percent return later; thus, the permanent attrition rate is approximately 70 percent of annual attrition. Teachers age 30–34 years tend to have the highest likelihood of returning; their permanent attrition rate is only about 65 percent of their annual attrition rate. For those 55 and over, almost all attrition is permanent.

Although future attrition rates will be the subject of another report that will present the results from an integrative model of teacher demand and supply, we note here that the strongest factors reducing attrition will likely continue in the immediate future, for example, over the next five to ten years. Women's labor-force participation rates will not reverse direction. On the other hand, we do not expect the rapid growth in women's participation rates that characterized the 1965–87 period. This means that further attrition declines as a result of this trend are unlikely.

Student-teacher ratios and teacher salary levels also may not show the strong positive trends evidenced in recent years. In Indiana, teacher salaries have increased significantly since 1982, and legislated declines in student-teacher ratios have also occurred. Further progress in salaries or student-teacher ratios will depend on educational funding and state policies. Many expect states and localities to face tighter fiscal conditions in the next 10 years as taxpayer revolts against increases in property taxes become more widespread, and demand for noneducational services increases at the state level, triggered by a shift in responsibility for some of these services from the federal government to states and localities.

Teacher attrition rates will begin to increase when the current, predominantly middle-aged force reaches retirement. The average age of teachers is currently 42, and over 50 percent of teachers are over 40. Although retirement eligibility begins at age 55, most will not retire until after age 60. The increase in retirement-associated attrition is expected to affect attrition rates strongly 10 to 20 years from now. Thus, attrition rates, although relatively stable in the near term, will begin to rise in the longer term.

One of the important methodological findings of this study is the need to analyze the attrition patterns of men and women separately. Supply and demand analyses that are based on overall combined data must be done with care and interpreted with caution.

In addition, there has been much misunderstanding of the appropriate teacher attrition rate to use in state and national models. At the national level, inappropriate use of attrition rates estimated from simplistic models of teacher supply and demand have led to predictions of shortages. We have shown here that it is crucial to distinguish between permanent and temporary attrition in these models. For example, annual attrition rates have ranged from 12–13 percent in the mid-60s to a low of 5 percent in 1987–88. However, permanent attrition rates are considerably lower, generally from 70–75 percent of annual attrition.

Perhaps we should reiterate that our viewpoint is, of course, that of the Indiana public school system. Many of the teachers we classify as permanent losses may return to teach in schools outside Indiana or in parochial schools in Indiana. Therefore, use of state attrition rates in national models is erroneous.

Attrition rates used in national models have been as high as 8 percent, and thus the magnitude of potential teacher shortages has been greatly exaggerated. We believe that national rates of attrition from teaching are currently in the 1–3 percent range. Use of such rates would mitigate concerns regarding overall teacher shortages, although our work also shows the potential for shortages in given specialties, especially those with easily transferable skills and in high demand by the private sector.

## FUTURE POLICY RESEARCH[2]

The Indiana longitudinal teacher files and the associated data describing the important variables over this period represent a significant investment in teacher research. A substantial amount of time and funds is needed for creating these data files—merging, editing, and checking for consistency. For files that extend over such long time periods the consistency of definitions of variables becomes a significant problem. In our case the definition of subject categories, school corporations, and even age changed over time, requiring us to go back to hard copy documentation and original historical records to resolve some of these issues. In the case of school corporations, consolidations over time meant that many school corporations disappeared, and new ones were created.

It is also necessary to gather ancilliary data such as wages for college graduates (age 25–29 years) and labor-force participation for this time period. For this we used Current Population Tapes from 1966–86.[3] The Indiana Department of Education provided much data on school corporations, student-teacher ratios, and anecdotal data about the RIFs of the late 1970s.

This analysis is the first attrition analysis with the Indiana longitudinal cohort file, but it represents only a small part of the potential research these data can support and the policy questions that can be addressed with these data.

The question of potential general teacher shortages that motivated this research appears on closer analysis not to be a serious issue in the next 10 years. Other issues will become more important. These include the early retirement of teachers, possible continuing shortages of specific types of teachers (mathematics/science), the supply of minority teachers, and the declining reserve pool. These are discussed below.

### Early Teacher Retirement

A likely scenario over the next 10 years is an education funding crisis. The teaching force will become even more skewed toward older teachers—primarily teachers age 40–60 years. These teachers will command salaries at the top of current scales, driving salary costs up. Together with increasing enrollments, these costs will demand growth in spending to maintain the current expenditures per pupil. It is unlikely that state funding will grow enough to accommodate these increased costs.

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[2] We are grateful to Diane Macunovich for suggestions incorporated here.

[3] We thank Diane Macunovich for generously sharing these data with us.

Early retirement of veteran teachers will become an important policy option for states trying to reduce education costs. Replacement of veteran teachers with younger teachers offers significant savings in terms of direct salary and benefit costs. Although early retirement offers will increase retirement costs, these costs are spread out over many years, and are usually not fully paid from annually appropriated funds. Research is required on current retirement patterns of teachers as well as the effects of early retirement offers on the decision to retire. Research is also required exploring whether the tradeoff of younger for older teachers is likely to increase or decrease average teacher quality.

### Minority Teachers

Declining black college enrollments threaten to lower the supply of minority teachers at a time when minority enrollments are rising. On the other hand, studies of state data have shown minority attrition rates to generally be lower than those of nonminority teachers. More specific analysis of minority supply and demand is required. Hispanic teachers also merit analysis, but the sample sizes generally are small except in certain states. Two states stand out as having large enough populations of both black and Hispanic teachers to justify an analysis. They are New York and Texas. Fortunately both of these states have fairly good data. A joint analysis of these two larger states would provide a much clearer picture of black and Hispanic teachers.

### Shortages of Science and Mathematics Teachers

Studies using state data (Michigan, North Carolina, and Indiana) have produced consistent results regarding subject-specific attrition rates. Attrition tends to be high among physics and chemistry teachers, as well as biology and mathematics teachers. In general, the attrition rates are from 40–70 percent higher for these groups than for elementary teachers. A surprising finding is that mathematics teachers have much lower attrition than physics/chemistry teachers.

This puts these disciplines at greater risk for shortages, but we have not yet modeled these individual groups in supply and demand models to assess the potential for additional shortages. More research is needed to discover the causes of the significant differences among types of science and math teachers. One hypothesis is that it simply reflects differences in outside job opportunities. Another is that laboratory teaching as opposed to classroom teaching is inherently more difficult, and there is greater sensitivity to quality of equipment and facilities. Finally the differences may reflect differences in gender attrition rates and the proportions by gender in each teaching area.

### The Declining Reserve Pool

Perhaps the most ominous trend is that the supply of returning and migrating teachers will be declining in future years. We currently depend on these teachers to fill about 50 percent of vacancies in any year. If there are fewer returning and migrating teachers, then we will need more younger teachers. Returning and migrating teachers will decline because of simple demographics. Teachers who return to teaching leave teaching most often at 25–35 years of age. Teacher migration also peaks during this age group. Since there are going to be fewer teachers in this age group as the teaching force ages, there will be fewer returning and migrating teachers to fill vacancies.

We need more research on the patterns of returning and migrating teachers to determine the precise decline in these pools over the next 10–15 years. Data available from several states could be readily used to explore these patterns and the subsequent decline in the reserve pool. This would tell us the timing of the much stronger demand for new teachers. If this occurs about the time of massive early retirements, a problem in supply could result. So this research needs to be combined with the early retirement research to determine the relative timing of the two phenomena.

## RESEARCH APPROACH

Research based on data from different states shows both similarities and differences in factors affecting state supply and demand. There is considerable similarity in age profiles of teachers and general attrition patterns among age groups and subject areas. There appear to be differences in the dependence on returning and migrating teachers to fill vacancies, the level of attrition, the number of new teacher graduates, the proportion of minorities, and early retirement programs and retirement patterns. These differences can arise from local or district policies, from state policies, or from differences in behavioral characteristics among teachers in different states.

Understanding these differences is important because supply and demand factors and the potential for shortages will change by state. It is also important because some states and districts have better policies and practices which can be identified and exported. Certain questions can also be better addressed by certain state data than others partly because data are available from some states for longer periods. Also some states have implemented programs such as early retirement and others have not.

However, the analysis of state data needs to be done within an integrated framework. Components of this framework are:

- Establishing common hypotheses that would form the basis of the research;
- Estimating attrition and other factors with the same model specifications;
- Using common definitions of variables across states; and
- Recognizing key differences across states that might need to be incorporated into the framework.

If the analysis of the state data is done within this framework, then we can distinguish between key national trends as opposed to within-state trends. Trends that are supported by data and analysis from several states are more persuasive than those based on analysis of only one state. Moreover, it is usually impossible to compare results of models done independently because of different model specifications and variable definitions. This type of analysis would also allow us to identify key differences caused by particular policies within states. For instance, does the pattern of teacher attrition rates vary by state, and what factors explain these differences?

Many methodological improvements would be desirable. Estimating time-varying covariate models would provide better estimates of effects. The Cox proportional hazards model treats all effects as proportional shifts to the entire hazard at all durations and this is unlikely to be true. Indeed, we have seen that even so crude a proxy as our salary growth ratio (that compared fourth-year salary to first-year salary) performed well in the model, suggesting the importance of allowing the regressors to vary over time.

Associating student-teacher ratios with individual school corporations rather than statewide averages would improve estimates of these effects. Including school corporation characteristics in the models would allow attrition to be linked with more specific characteristics of school districts.

Finally, attrition estimates need to be placed in the context of a larger model that integrates teacher supply and demand. In a future report we will present the elements of such a model and provide some preliminary results, but much work remains to be done in the development of this model and in integrating the supply and demand components.

## Appendix

# REGRESSION ESTIMATES FOR COX MODELS OF TEACHER ATTRITION

## Table A.1

### PARAMETER ESTIMATES FOR COX REGRESSION ON TIME TO ANNUAL ATTRITION FROM TEACHING, 1965–82 COHORTS: COMBINED SAMPLE

| | Dependent Variable: Annual Attrition | | | | | |
|---|---|---|---|---|---|---|
| | I | | | II | | |
| Variable | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. |
| Age at entry | | | | | | |
| 20-24 | 0.054 | 1.055 | 2.232* | 0.014 | 1.014 | 0.584 |
| 30+ | –0.500 | 0.606 | –12.607** | –0.557 | 0.573 | –13.956** |
| Gender | | | | | | |
| Male | –0.433 | 0.649 | –18.712** | –0.459 | 0.632 | –19.748** |
| Subject specialty | | | | | | |
| Special education | –0.047 | 0.955 | –1.206 | 0.081 | 1.084 | 2.041* |
| English | 0.221 | 1.248 | 7.310** | 0.221 | 1.247 | 7.286** |
| Mathematics | 0.061 | 1.064 | 1.476 | 0.095 | 1.099 | 2.259* |
| Physics/chemistry | 0.444 | 1.558 | 3.340** | 0.462 | 1.586 | 3.472** |
| Biology | 0.338 | 1.403 | 3.265** | 0.340 | 1.405 | 3.276** |
| Other science | 0.216 | 1.241 | 2.541* | 0.107 | 1.113 | 1.253** |
| Other departmental | 0.132 | 1.141 | 5.497** | 0.156 | 1.168 | 6.470** |
| Cohort year | | | | | | |
| 1968–70 | — | — | — | –0.137 | 0.872 | –5.109** |
| 1971–73 | — | — | — | –0.353 | 0.703 | –12.100** |
| 1974–76 | — | — | — | –0.491 | 0.612 | –14.725** |
| 1977–79 | — | — | — | –0.397 | 0.673 | –11.011** |
| 1980–82 | — | — | — | –0.483 | 0.617 | –9.837** |

NOTES: The omitted categories are age 25–29, female, teaching nondepartmental elementary. In Model II, the omitted group includes those entering in 1965–67. * Significant at the 0.05 level. ** Significant at the 0.01 level.

## Table A.2

## PARAMETER ESTIMATES FOR COX REGRESSION ON TIME TO PERMANENT ATTRITION FROM TEACHING, 1965–82 COHORTS: COMBINED SAMPLE

| Variable | Dependent Variable: Permanent Attrition | | | | | |
|---|---|---|---|---|---|---|
| | I | | | II | | |
| | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. |
| Age at entry | | | | | | |
| 20–24 | –0.050 | 0.952 | –1.867 | 0.014 | 1.014 | 0.584 |
| 30+ | –0.289 | 0.751 | –6.762** | –0.557 | 0.573 | –13.956** |
| Gender | | | | | | |
| Male | –0.197 | 0.821 | –7.812 | –0.459 | 0.632 | –19.748** |
| Subject specialty | | | | | | |
| Special education | 0.069 | 1.072 | 1.604 | 0.081 | 1.084 | 2.041* |
| English | 0.258 | 1.294 | 7.632** | 0.221 | 1.247 | 7.286** |
| Mathematics | 0.188 | 1.206 | 4.125** | 0.095 | 1.099 | 1.259* |
| Physics/chemistry | 0.520 | 1.682 | 3.701** | 0.462 | 1.586 | 3.472** |
| Biology | 0.440 | 1.553 | 3.943** | 0.340 | 1.405 | 3.276** |
| Other science | 0.206 | 1.228 | 2.191** | 0.107 | 1.113 | 1.253 |
| Other departmental | 0.207 | 1.230 | 7.709** | 0.156 | 1.168 | 6.470** |
| Cohort year | | | | | | |
| 1968–70 | — | — | — | –0.137 | 0.872 | –5.109** |
| 1971–73 | — | — | — | –0.353 | 0.703 | –12.100** |
| 1974–76 | — | — | — | –0.491 | 0.612 | –14.725** |
| 1977–79 | — | — | — | –0.397 | 0.673 | –11.011** |
| 1980–82 | — | — | — | –0.483 | 0.617 | –9.837** |

NOTES: The omitted categories are age 25–29, female, teaching nondepartmental elementary. In Model II, the omitted group includes those entering in 1965–67. * Significant at the 0.05 level. ** Significant at the 0.01 level.

## Table A.3

## PARAMETER ESTIMATES FOR COX REGRESSION ON TIME TO ANNUAL ATTRITION FROM TEACHING, 1965–82 COHORTS: MEN

| | Dependent Variable: Annual Attrition | | | | | |
|---|---|---|---|---|---|---|
| | I | | | II | | |
| Variable | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. |
| Age at entry | | | | | | |
| 20–24 | –0.055 | 0.947 | –1.324 | –0.063 | 0.939 | –1.516 |
| 30+ | 0.145 | 1.156 | 1.879 | 0.141 | 1.151 | 1.825 |
| Subject specialty | | | | | | |
| Special education | 0.352 | 1.422 | 3.097** | 0.397 | 1.487 | 3.469** |
| English | 0.421 | 1.523 | 6.251** | 0.421 | 1.524 | 6.256** |
| Mathematics | 0.129 | 1.137 | 1.907 | 0.128 | 1.136 | 1.895 |
| Physics/chemistry | 0.552 | 1.736 | 3.579** | 0.545 | 1.724 | 3.529** |
| Biology | 0.437 | 1.549 | 3.267** | 0.431 | 1.539 | 3.217** |
| Other science | 0.263 | 1.301 | 2.382* | 0.217 | 1.242 | 1.949 |
| Other departmental | 0.190 | 1.210 | 4.033** | 0.198 | 1.219 | 4.192** |
| Cohort year | | | | | | |
| 1968–70 | — | — | — | –0.039 | 0.962 | –0.741 |
| 1971–73 | — | — | — | –0.160 | 0.852 | –2.805** |
| 1974–76 | — | — | — | –0.197 | 0.821 | –3.144** |
| 1977–79 | — | — | — | –0.040 | 0.961 | –0.600 |
| 1980–82 | — | — | — | –0.346 | 0.708 | –3.628** |

NOTES: The omitted categories are age 25–29, female, teaching nondepartmental elementary. In Model II, the omitted group includes those entering in 1965–67. * Significant at the 0.05 level. ** Significant at the 0.01 level.

## Table A.4

### PARAMETER ESTIMATES FOR COX REGRESSION ON TIME TO PERMANENT ATTRITION FROM TEACHING, 1965–82 COHORTS: MEN

| | Dependent Variable: Permanent Attrition | | | | | |
|---|---|---|---|---|---|---|
| | I | | | II | | |
| Variable | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. |
| Age at entry | | | | | | |
| 20–24 | –0.137 | 0.872 | –3.149** | –0.138 | 0.871 | –3.159** |
| 30+ | 0.194 | 1.214 | 2.431* | 0.184 | 1.201 | 2.296** |
| Subject specialty | | | | | | |
| Special education | 0.284 | 1.329 | 2.310* | 0.303 | 1.353 | 2.446* |
| English | 0.394 | 1.484 | 5.430** | 0.393 | 1.481 | 5.403** |
| Mathematics | 0.187 | 1.206 | 2.608** | 0.186 | 1.205 | 2.590* |
| Physics/chemistry | 0.537 | 1.711 | 3.282** | 0.519 | 1.680 | 3.167** |
| Biology | 0.501 | 1.651 | 3.518** | 0.506 | 1.658 | 3.546** |
| Other science | 0.187 | 1.206 | 1.548 | 0.167 | 1.182 | 1.368 |
| Other departmental | 0.214 | 1.239 | 4.224** | 0.214 | 1.239 | 4.222** |
| Cohort year | | | | | | |
| 1968–70 | — | — | — | 0.002 | 1.002 | 0.032 |
| 1971–73 | — | — | — | –0.083 | 0.921 | –1.340 |
| 1974–76 | — | — | — | –0.165 | 0.848 | –2.416* |
| 1977–79 | — | — | — | 0.006 | 1.006 | 0.089 |
| 1980–82 | — | — | — | 0.020 | 1.021 | 0.224 |

NOTES: The omitted categories are age 25–29, female, teaching nondepartmental elementary. In Model II, the omitted group includes those entering in 1965–67. * Significant at the 0.05 level. ** Significant at the 0.01 level.

## Table A.5

## PARAMETER ESTIMATES FOR COX REGRESSION ON TIME TO ANNUAL ATTRITION FROM TEACHING, 1965–82 COHORTS: WOMEN

| | Dependent Variable: Annual Attrition | | | | | |
|---|---|---|---|---|---|---|
| | I | | | II | | |
| Variable | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. |
| Age at entry | | | | | | |
| 20–24 | 0.104 | 1.110 | 3.472** | 0.037 | 1.038 | 1.216 |
| 30+ | –0.626 | 0.535 | –13.477** | –0.720 | 0.487 | –15.389** |
| Subject specialty | | | | | | |
| Special education | –0.106 | 0.900 | –2.577** | 0.062 | 1.064 | 1.463 |
| English | 0.176 | 1.192 | 5.158** | 0.175 | 1.192 | 5.141** |
| Mathematics | 0.060 | 1.062 | 1.088 | 0.144 | 1.155 | 2.587** |
| Physics/chemistry | 0.233 | 1.263 | 0.839 | 0.403 | 1.497 | 1.450 |
| Biology | 0.283 | 1.327 | 1.664 | 0.324 | 1.382 | 1.906 |
| Other science | 0.301 | 1.351 | 2.156* | 0.188 | 1.207 | 1.347 |
| Other departmental | 0.118 | 1.125 | 4.115** | 0.143 | 1.153 | 4.975** |
| Cohort year | | | | | | |
| 1968–70 | — | — | — | –0.180 | 0.836 | –5.712** |
| 1971–73 | — | — | — | –0.433 | 0.648 | –12.755** |
| 1974–76 | — | — | — | –0.621 | 0.537 | –15.741** |
| 1977–79 | — | — | — | –0.550 | 0.577 | –12.804** |
| 1980–82 | — | — | — | –0.563 | 0.569 | –9.789** |

NOTES: The omitted categories are age 25–29, female, teaching nondepartmental elementary. In Model II, the omitted group includes those entering in 1965–67. * Significant at the 0.05 level. ** Significant at the 0.01 level.

## Table A.6

### PARAMETER ESTIMATES FOR COX REGRESSION ON TIME TO PERMANENT ATTRITION FROM TEACHING, 1965–82 COHORTS: WOMEN

| | Dependent Variable: Permanent Attrition | | | | | |
|---|---|---|---|---|---|---|
| | I | | | II | | |
| Variable | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. |
| Age at entry | | | | | | |
| 20–24 | –0.008 | 0.993 | –0.222 | –0.046 | 0.955 | –1.343 |
| 30+ | –0.385 | 0.681 | –7.665** | –0.434 | 0.648 | –8.610** |
| Subject specialty | | | | | | |
| Special education | 0.034 | 1.034 | 0.727 | 0.123 | 1.131 | 2.588** |
| English | 0.222 | 1.248 | 5.771** | 0.222 | 1.248 | 5.768** |
| Mathematics | 0.216 | 1.242 | 3.525** | 0.258 | 1.294 | 4.182** |
| Physics/chemistry | 0.484 | 1.623 | 1.674 | 0.601 | 1.824 | 2.077* |
| Biology | 0.375 | 1.455 | 2.009* | 0.395 | 1.485 | 2.117* |
| Other science | 0.348 | 1.416 | 2.236* | 0.275 | 1.317 | 1.767 |
| Other departmental | 0.206 | 1.228 | 6.347** | 0.219 | 1.244 | 6.730** |
| Cohort year | | | | | | |
| 1968–70 | — | — | — | –0.135 | 0.873 | –3.774** |
| 1971–73 | — | — | — | –0.321 | 0.726 | –8.259** |
| 1974–76 | — | — | — | –0.461 | 0.631 | –10.200** |
| 1977–79 | — | — | — | –0.393 | 0.675 | –7.983** |
| 1980–82 | — | — | — | –0.114 | 0.893 | –1.935 |

NOTES: The omitted categories are age 25–29, female, teaching nondepartmental elementary. In Model II, the omitted group includes those entering in 1965–67. * Significant at the 0.05 level. ** Significant at the 0.01 level.

## Table A.7

## PARAMETER ESTIMATES FOR COX REGRESSION ON TIME TO ATTRITION FROM TEACHING, 1965–82 COHORTS: FIRST FOUR YEARS OF TEACHING, ANNUAL ATTRITION

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| Variable | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. | Beta Coefficient | Multiplicative Factor exp (Beta) | t-stat. |
| Age of entry | | | | | | |
| 20–24 | –0.084 | 0.920 | –1.552 | –0.070 | 0.932 | –1.845 |
| 30+ | 0.159 | 1.172 | 1.589 | –0.922 | 0.398 | –13.646** |
| Subject specialty | | | | | | |
| Special education | 0.323 | 1.382 | 2.226* | 0.103 | 1.109 | 1.880 |
| English | 0.391 | 1.478 | 4.498** | 0.231 | 1.260 | 5.359** |
| Mathematics | 0.055 | 1.057 | 0.607 | 0.249 | 1.283 | 3.626** |
| Physics/chemistry | 0.558 | 1.747 | 3.030** | 0.462 | 1.587 | 1.381 |
| Biology | 0.252 | 1.267 | 1.369 | 0.458 | 1.581 | 2.275* |
| Other science | 0.262 | 1.300 | 1.834 | 0.348 | 1.416 | 2.096* |
| Other departmental | 0.173 | 1.189 | 2.753** | 0.171 | 1.187 | 4.624** |
| Base salary (1987 $ 000s) | –0.054 | 0.947 | –3.665** | –0.022 | 0.978 | –1.792 |
| Student-teacher ratio | 0.107 | 1.113 | 2.008* | 0.016 | 1.016 | 0.33[illegible] |
| Labor-force participation rate | 1.170 | 3.222 | 0.587 | –2.853 | 0.058 | –3.253** |
| Median income of full-time workers (1980 $ 000s) | 0.008 | 1.008 | 0.105 | 0.092 | 1.096 | 1.483 |
| Salary growth ratio (4th year salary/base salary) | 0.478 | 1.613 | 0.484 | –2.846 | 0.058 | –3.510** |
| 1977 | 0.283 | 1.328 | 2.050* | 0.362 | 1.436 | 3.204** |
| 1978 | 0.387 | 1.473 | 2.889** | 0.508 | 1.662 | 3.802** |
| 1979 | 0.338 | 1.402 | 2.428* | 0.505 | 1.657 | 4.475** |
| 1980 | 0.384 | 1.468 | 2.327* | 0.330 | 1.390 | 2.986** |

NOTES: The omitted categories are age 25–29, female, teaching nondepartmental elementary. In Model II, the omitted group includes those entering in 1965–67. * Significant at the 0.05 level. ** Significant at the 0.01 level.

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